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ESTIMATING USACE CIVIL WORKS PROJECT COSTS

Report AR801R2

January 1989

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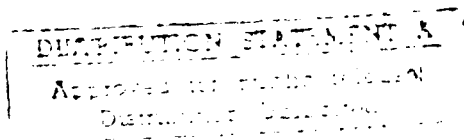
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The U.S. Army Corps of Engineers (USACE) provided $7 billion worth of design, engineering, design and engineering management, and construction management services for the military construction (MILCON) and the civil works programs in FY88. Since cost control is a major part of USACE's management responsibilities, their customers expect strict control of authorized funds and adherence to established budgets. This expectation has been heightened by the decreased MILCON budgets of recent years and by legislative initiatives such as the Water Resource Development Act of 1986.

In this report, we present the results of our statistical analysis of a thousand civil works projects and propose equations for estimating engineering and construction management costs for various types of projects.

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Executive Summary

ESTIMATING USACE CIVIL WORKS PROJECT COSTS

The United States Army Corps of Engineers (USACE) provides engineering and construction management services for a $1 billion annual civil works program. In 1974, USACE analyzed the historic cost of providing these services and developed curves that could be used to estimate the engineering and construction management costs for certain categories of civil works projects. These curves are used by USACE managers to monitor costs and to assess the reasonableness of cost estimates.

Our analysis showed that the nature of civil works projects have changed since the 1974 study. These cost curves used by USACE are dated. Changes in procedures and construction techniques mean that the old equations may no longer be valid. We found that a greater precision in cost estimating could be attained by increasing the categories of projects examined from five to seventeen. We developed cost estimating equations for these seventeen categories of projects and have incorporated them into a civil works cost estimating model.

We recommend that the Director of Engineering and Construction use this model to estimate engineering and construction management costs once a project has been developed and to monitor these costs during project execution. This model should be made available to USACE divisions and districts and should become part of an overall USACE cost management strategy. We believe the model can be an effective tool for enhancing USACE cost performance.

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CHAPTER 1

INTRODUCTION

The United States Army Corps of Engineers (USACE) provides engineering and construction management services for a $1 billion annual civil works program. In 1974, USACE analyzed the historic cost of providing these services and developed curves that could be used to estimate the engineering and construction management costs for five categories of civil works projects. This analysis produced a series of curves that related USACE direct engineering and design (E&D), supervision and inspection (S&I),[1] technical indirect, and general administrative overhead (G&A) costs to the construction cost of a project. The curves were based on civil works projects that had been completed in the 10-year period before 1974.

These cost curves are used by USACE civil works project managers to monitor costs and to assess the reasonableness of cost estimates for USACE civil works projects. Over the years, the cost curves have proved to be effective management tools. However, today, these cost curves are dated. Changes in procedures and new construction techniques have raised questions about their validity. Additionally, the original curves were limited to channel, flood protection, floodwalls and drainage, dredging, and lock and dam projects and did not distinguish between new construction, maintenance, or rehabilitation work. New curves are needed that are based on data from more recent projects and from an expanded list of project categories.

Our initial analysis indicated that civil works projects could be divided into 17 distinct categories (see Table 1-1). The categories were established after considering the type of work — new construction, maintenance, or rehabilitation — coupled with the functional purpose of the project. Table A-2 in Appendix A maps civil works fund types into the 17 project categories.

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[1] Supervision and inspection costs are the direct costs associated with the construction management of a project. They are a subset of the supervision and administration costs which also include indirect costs.

TABLE 1-1

USACE CIVIL WORKS PROJECT CATEGORIES

Channels and harbors

Locks and dams

Beach erosion

Flood control

Flood control reservoirs

Multipurpose power

Rehabilitation: channels and harbors

Rehabilitation: locks and dams

O&M: channels and harbors

O&M: locks and dams

O&M: flood control

O&M: flood control reservoirs

O&M: multipurpose power

O&M: channel and harbor improvements

Flood control: rehabilitation

Flood control: construction

Recreation

We believe this categorization scheme provides for a homogeneous grouping of the diverse civil works projects. These categories were the basis for the data collection and analysis efforts.

Cost data for civil works projects can be obtained from four different USACE sources. Most cost information is maintained in the Corps of Engineers Management Information System (COEMIS), but costs are also maintained in the Automated Projects Reporting System (AMPRS), the Project Reporting Information System for Management (PRISM), and manual cost records. We found that no single source could provide all of the information for all districts and concluded that a district data call was required.

A data call was structured and sent to all USACE districts with a civil works mission. (See Appendix A for data definitions and a copy of the data call.) The data call requested information on completed civil works projects. Information was either reported on a project basis or, in those cases where a project could be broken down

into a number of separate and distinct contracts, on a contract basis. When a contract was used as the basis for reporting, districts were instructed to ensure that planning, general design memorandum/final design memorandum (GDM/FDM), and other project-wide costs were pro-rated to contracts within the project. The district responses used combinations of the four potential data sources. Cost data for some older projects were only available in manual records, while for others, automated systems were utilized exclusively.

Although the data definitions are based upon feature/sub-feature and accounting element level of detail, judgment is still required to categorize certain costs. This is particularly true for allocating planning and engineering costs. We defined engineering costs to include GDM and FDM costs as well as any other design or engineering costs. From our statistical examination of the raw data, we believe the apportionment of planning and design costs was correct in most cases and was not a major source of error in the analysis.

A total of 37 districts reported usable information on 974 civil works projects. Table 1-2 shows the response by district and Table 1-3 shows the number of projects by category.

The project data were edited for internal consistency — making certain that the sum of the pieces equaled the totals — and for reasonableness when compared to data from other districts. Data outliers identified by editing were confirmed with the reporting districts and corrected when necessary. The resultant data set was then analyzed statistically to produce the new cost curves.

TABLE 1-2

DISTRICT RESPONSE

District	Number of projects	Percent of total
Memphis	17	1 7%
New Orleans	9	0.9
Vicksburg	8	0 8
Kansas City	10	1.0
Omaha	67	6 9
New England	37	3.8
Baltimore	10	1.0
New York	11	1.1
Norfolk	2	0 2
Philadelphia	81	8.3
Buffalo	127	13.0
Chicago	41	4.2
Detroit	68	7.0
Rock Island	46	4.7
St. Paul	33	3 4
Alaska	14	1 4
Portland	17	1 7
Seattle	41	4 2
Walla Walla	11	1.1
Huntington	12	1 2
Louisville	16	1 6
Nashville	8	0 8
Pittsburgh	9	0.9
Pacific Ocean	49	5 0
Charleston	6	0 6
Jacksonville	14	1.4
Mobile	83	8.5
Savannah	6	0 6
Wilmington	18	1.8
Los Angeles	18	1 8
Sacramento	6	0 6
San Francisco	18	1 8
Albuquerque	4	0 4
Fort Worth	11	1 1
Galveston	14	1 4
Little Rock	8	0 8
Tulsa	24	2.5
Total	974	100.0%

TABLE 1-3

DISTRIBUTION OF PROJECTS BY CATEGORY

Category	Number of projects	Percent of total
Channel/harbor	116	11 9%
Locks/dams	23	2.4
Beach erosion	44	4 5
Flood control	271	27 8
F/C: reservoir	54	5.5
Multipurpose power	22	2.3
Rehab: channel/harbor	9	0 9
Rehab: locks/dams	14	1.4
O&M: channel/harbor	268	27 5
O&M: locks/dams	14	1 4
O&M: flood control	8	0.8
O&M: F/C reservoir	2	0.2
O&M: M/P power	51	5.2
O&M: C/H improvement	4	0.4
F/C: rehabilitation	26	2 7
F/C: construction	22	2.3
Recreation	26	2.7
Total	974	100.0%

CHAPTER 2

RESULTS OF ANALYSIS AND RECOMMENDATIONS

DESCRIPTION OF REGRESSION ANALYSIS

Separate regression equations (with USACE project costs as a function of the construction contract amount) were estimated for each project category for six different USACE costs: total engineering, direct engineering and design (E&D), technical indirect, supervision and administration (S&A), supervision and inspection (S&I), and general and admnistrative (G&A). Actual USACE costs were used as the dependent variable instead of the cost ratios, because estimating costs, not ratios, was the purpose of this analysis. The equations were estimated with a zero intercept (through the origin). Equations with an intercept (a fixed component) were examined initially but found to be statistically insignificant.

Since previous USACE cost curves had reflected economies of scale (lower cost ratios for larger projects), several nonlinear models were also tested. A model which used the square of the independent variable — a common form for reflecting economies of scale — was rejected because the resulting cost estimates decrease as project size increases for large projects within the relevant range. A model which used dummy variables for large projects was rejected because the resulting cost estimates were unstable near the project size threshold. Finally, models which used the log or square root of the independent variable had the desirable theoretical properties, but the square root model had consistently greater explanatory power (adjusted R-Square) than the log models and was therefore chosen as the nonlinear alternative.

DATA AND SAMPLE SIZE ISSUES

In order to produce internally consistent and meaningful equations, only those projects with valid data for all the relevant costs were included in the regression analysis. The resulting sample sizes were therefore smaller than those shown in Table 1-3. Furthermore, several of the project categories in the data call produced sample sizes too small for reliable statistical results. We combined those categories with small sample sizes with similar project categories to create sample sizes large

enough to provide reliable statistics. Consequently, the original 17 categories were consolidated into 8 for the regression analysis.

Because of the limited data available on planning, supervision and review (S&R), and area office overhead costs, the regression equations for these three variables had to be estimated based on the entire data call sample. In addition, because of the nature of S&R costs, it was more appropriate to use the architect-engineer (AE) contract amount as the independent variable in the S&R equation rather than the construction contract amount.

SUMMARY OF RESULTS

For each of the 48 category-level regression equations, Table 2-1 displays the estimated coefficient, the t statistic for that coefficient, the adjusted R-Square for the equation, the model selected (the alternative — linear or nonlinear — which produced a better fit for the six costs), and the number of projects on which the estimates were based. Economies of scale were found (i.e., the square root model outperformed the linear model) for four of the eight categories. The estimated coefficients were all significant at the 99.9 percent level, and the adjusted R-Square exceeded 0.70 for most of the equations.

Table 2-2 summarizes the results for the other three models. The adjusted R-Squares for the planning and area office overhead equations were fairly low, reflecting the necessary combining of different project categories and the indirect nature of those costs, but the estimated coefficients were both highly significant and economies of scale were found to prevail. A much stronger (and more linear) relationship was found between S&R costs and the AE contract amount, even though the equation was based on many different types of projects.

GENERAL INTERPRETATION OF RESULTS

The analysis confirms that USACE costs vary widely, even among similar projects, but reasonable cost estimates can still be made based on a project's type and size. However, the nature of the relationship between project size and USACE cost depends upon the type of project. For four of the eight categories — Channel/Harbor, Locks/Dams, Flood Control, and Flood Control Reservoir — there are economies of scale. For the remaining four categories, there are no significant economies of scale (i.e., the cost ratios do not depend upon project size).

TABLE 2-1

SUMMARY OF USACE COST REGRESSIONS FOR SPECIFIC PROJECT CATEGORIES

Project categories		Total engineering costs	Direct E&D costs	Technical indirect costs	S&A costs	S&I costs	G&A costs
Channel/Harbor	Coefficient	301	200	21	166	151	50
	T Statistic	113	140	55	152	148	84
	Adj R-Square	062	072	028	075	074	048
	Model Type*	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear
	Sample Size	76	76	76	76	76	76
O&M Channel/Harbor	Coefficient	071	056	007	050	043	015
Rehab Channel Harbor	T Statistic	137	124	105	212	205	107
O&M C/H Improvement	Adj R Square	054	050	041	074	073	042
	Model Type	Linear	Linear	Linear	Linear	Linear	Linear
	Sample Size	155	155	155	155	155	155
Locks Dams	Coefficient	1,489	893	190	725	567	226
Rehab Locks Dams	T Statistic	83	138	67	215	147	130
O&M Locks Dams	Adj R Square	066	084	056	093	086	083
	Model Type	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear
	Sample Size	35	35	35	35	35	35
Flood Control	Coefficient	592	481	52	235	163	88
	T Statistic	198	195	134	249	278	180
	Adj R Square	068	067	049	077	081	064
	Model Type	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear
	Sample Size	184	184	184	184	184	184
F C Reservoir	Coefficient	923	775	94	433	324	196
O&M F C Reservoir	T Statistic	138	143	64	218	192	148
	Adj R Square	081	082	047	091	089	083
	Model Type	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear	Nonlinear
	Sample Size	45	45	45	45	45	45

* Construction contract amount is the independent variable for linear models. Square root of construction contract amount is the independent variable for nonlinear models.

TABLE 2-1

SUMMARY OF USACE COST REGRESSIONS FOR SPECIFIC PROJECT CATEGORIES (Continued)

Project categories		Total engineering costs	Direct E&D costs	Technical indirect costs	S&A costs	S&I costs	G&A costs
O&M Flood Control F/C Rehabilitation F/C Construction	Coefficient	154	113	041	072	053	023
	T Statistic	125	130	112	346	757	105
	Adj R Square	082	083	079	097	099	076
	Model Type	Linear	Linear	Linear	Linear	Linear	Linear
	Sample Size	34	34	34	34	34	34
Multipurpose Power O&M M/P Power	Coefficient	117	090	017	028	022	014
	T Statistic	199	309	90	220	181	172
	Adj R Square	091	096	066	092	089	088
	Model Type	Linear	Linear	Linear	Linear	Linear	Linear
	Sample Size	41	41	41	41	41	41
Beach Erosion Recreation	Coefficient	089	069	012	044	035	017
	T Statistic	91	84	46	125	94	113
	Adj R Square	061	057	028	075	063	071
	Model Type	Linear	Linear	Linear	Linear	Linear	Linear
	Sample Size	52	52	52	52	52	52

TABLE 2-2

SUMMARY OF USACE COST REGRESSIONS FOR ALL CIVIL WORKS PROJECTS

Planning costs	Independent variable	Construction amount
	Model type	Nonlinear
	Sample size	246
	Coefficient	46
	T Statistic	10.9
	Adjusted R-Square	0.32
Area office overhead costs	Independent variable	Construction amount
	Model type	Nonlinear
	Sample size	172
	Coefficient	22
	T Statistic	7.4
	Adjusted R-Square	0.24
Supervision & review costs	Independent variable	AE contract amount
	Model type	Linear
	Sample size	206
	Coefficient	.166
	T Statistic	18.0
	Adjusted R-Square	0.61

The ability to accurately estimate USACE costs differs by type of project and type of cost. For example, the Multipurpose Power equations had the highest adjusted R-Squares and t statistics of the eight project categories, while the Operations and Maintenance (O&M) Channel/Harbor equations had the lowest. Similarly, the S&A equations had the highest adjusted R-Squares and t statistics of the six different costs that were estimated at the category level, while the technical indirect equations had the lowest. Finally, the regression coefficients show that engineering services (as measured by total design or direct E&D costs) are consistently more expensive than construction management services (as measured by S&A costs).

RECOMMENDATIONS REGARDING USE OF RESULTS

These regression equations update the cost curves developed by USACE in the 1970s, reflecting changes in economic conditions, management policies, and accounting practices. The new equations also cover a broader spectrum of USACE costs (although equations have not yet been developed for planning or operations costs), while incorporating a more detailed and more comprehensive classification of USACE projects.

For project categories with nonlinear equations (economies of scale), the estimated cost equals the regression coefficient times the square root of the construction contract amount (in millions). For project categories with linear equations (no economies of scale), the estimated cost equals the regression coefficient times the construction contract amount (in millions).

The results can be used to help project managers estimate what the actual costs are likely to be for specific projects, to help USACE headquarters staff estimate resource requirements for a given customer, division, program, etc., and to help district and division staff identify potential problem areas by comparing actual project costs to the average cost of similar projects. However, it is important to note that the equations are in "constant dollars," so the cost estimates are in the same year's dollars as the construction contract amount (or the AE contract amount, in the case of S&R costs). The estimates must therefore be adjusted — using DoD deflators or other inflation indexes — to obtain results expressed in a different year's dollars.

Finally, attention should be paid to ongoing data collection through existing or planned automated systems which can be used to periodically update the results produced by this analysis or to develop cost curves or equations for USACE planning and operations costs. The civil works data call was conducted because the project-level data available from current USACE automated information systems were inadequate. If these shortcomings are resolved, future analysis can be based entirely on data from automated systems with much less effort.

CIVIL WORKS COST ESTIMATING MODEL

A microcomputer-based cost estimating model was developed to facilitate the use of the information from the statistical analysis. This model utilizes the equations described in the previous sections to estimate USACE costs associated

with civil works projects and then to compare these costs with the distribution of similar USACE projects obtained from the data call. It is an automated way to use the results of this analysis to monitor and manage USACE civil works project costs. A description of that model and instructions on its use are contained in the *Civil Works Cost Model Users Guide.*

APPENDIX A

CIVIL WORKS DATA CALL

TABLES

FIGURES

FIGURES (Continued)

FIGURES (Continued)

FIGURES (Continued)

FIGURES (Continued)

CIVIL WORKS DATA CALL

BACKGROUND

The civil works data call was initiated in April 1988 by the Director of Engineering and Construction and the Director of Resource Management. The data call forms and data element definitions used in this data call are shown in Figure A-1 and Table A-1, respectively. The data call was necessary since no single U.S. Army Corps of Engineers (USACE) information source could provide all the needed data. Thus, it was necessary for USACE divisions and districts to use combinations of available data sources — Corps of Engineers Management Information System (COEMIS), Automated Projects Reporting System (AMPRS), Project Reporting Information System for Management (PRISM), and manual cost systems — to meet the requirements of the data call.

DATA COLLECTION AND ANALYSIS

Data on nearly 1,000 civil works projects were collected from 35 districts and 2 operating divisions. Those data were subjected to a series of manual and computer edits in which blank, duplicate, or invalid projects were deleted; projects with missing, invalid, or extreme values were identified; and the data in question were checked and corrected where necessary. All zero entries were treated as missing values. The resulting analysis sample contained 974 projects.

COEMIS project identification codes and civil works appropriation codes were then used to classify the projects into 17 categories. The classification scheme (see Table A-2) was jointly developed by LMI and USACE and provides a basis for comparisons with military and private-sector projects.

The cost data were adjusted for inflation. Since data on project costs by year were unavailable, we assumed that total engineering, planning, architect-engineer (AE) contracting, supervision and review (S&R), engineering and design (E&D), and design-related general and administrative (G&A) costs were incurred at the mid-point of the design phase; and that supervision and administration (S&A), supervision and inspection (S&I), and construction-related G&A costs were incurred

DISTRICT

Data Item Number	1 EROC	2 Project (or Contract) Description	3 CWIS Number	4 COEMIS Project Code	5 Civil Code	6 Design Start Date	7 Design Completion Date	8 Construction Start Date
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

FIG. A-1. DATA CALL FORMS

DISTRICT

Data Item Number	9 Construction Completion Date	10 Construction Contract Amount	11 Design Costs		12 A&E Contract Amount	13 Design S&R Costs	14 Direct E&D Costs	15 Tech Indirect E&D Costs	16 Construction S&A Costs
			11a Planning	11b Design					
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

FIG. A-1. DATA CALL FORMS (Continued)

DISTRICT

Data Item Number	17 Construction S&I Costs	18 G&A Costs	19 Area Office Overhead	20 Project Location (City)	Project Location (Zip)	21 Project Location (State)	22 Total Engineering Manhours	23 Total Construction Manhours
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

FIG. A-1. DATA CALL FORMS (Continued)

TABLE A-1

DEFINITION OF DATA ELEMENTS

Note: Include only contracts or portions of projects that are 100 percent physically completed. A project may be split into a number of contracts and each contract can be treated as a separate project for data collection purposes.

1. EROC – Code identifying the District performing the work.

2. Project Description – The name or brief description of the project, such as that used in the AMPRS database.

3. CWIS Number – The Civil Works Identification System number.

4. COEMIS 5-Digit Project Code – The COEMIS project identification code.

5. Civil 3-Digit Category, Class, and Subclass Code – The civil works appropriation code (ER 37-2-10, APP 20-I). Supply all codes if multiple codes apply to one project.

6. Design Start Date – The General Design Memorandum (GDM) approval date.

7. Design Completion Date – The date on which design was completed.

8. Construction Start Date – The date on which construction started following notice to proceed.

9. Construction Completion Date – The date on which construction was physically completed (NOT the date of financial completion).

10. Construction Contract Amount – The final dollar amount of the construction contract, including contingencies and modifications.

11. Design Costs –

    a. All costs for planning to include reconnaissance and feasibility studies. These are costs included in features 501, 502, 503, and 505 (ER 37-2-10, pp 8-5a and 8-5b).

    b. All design costs for GDM and Final Design Memorandum (FDM) preparation as well as any other design costs. These are costs included in features 501, 502, 503, and 505 (ER 37-2-10, pp. 8-5a and 8-5b).

12. AE Contract Amount – The total contracted costs for contracted-out engineering and design effort. Feature 30.1 (ER 37-2-10, p 8-14).

13. Design Supervision and Review Costs – The costs for supervision and review of contracted-out engineering and design work. Feature 30 2 (ER 37-2-10 pp. 8-14).

14. Direct In-house Engineering and Design Costs – The costs for in-house engineering and design effort. Features 30.4, 30.5, and 30.6 (ER 37-2-10, pp. 8-14 and 8-15)

15. Technical Indirect Engineering and Design Costs – The technical indirect costs for in-house engineering and design effort. Accounting element 232 for features 30.4, 30.5, and 30.6 (ER 37-2-10, pp. 8-14 and 8-15).

16. Construction Supervision and Administration Costs (S&A) – The costs of supervising and administrating construction projects (including supervision and inspection costs). Feature 31 (ER 37-2-10, pp. 8-15 and 8-16).

(Continued)

TABLE A-1

DEFINITION OF DATA ELEMENTS (Continued)

17. Construction Supervision and Inspection Costs (S&I) – The costs of supervising and inspecting construction projects (included in S&A above). Features 31.1 through 31.32 inclusive (ER 37-2-10, pp 8-15).

18. General and Administrative Costs (G&A) – The total district overhead costs of the project (for both engineering and construction), not including Area Office overhead. All accounting element 351 costs (excluding Real Estate).

19. Area Office Overhead – The Area Office overhead costs of the project (use zero if no overhead). All accounting element 352 costs.

20. Project Location, City – The city or town at or near the project (including 5-digit zip code if available).

21. Project Location, State – The primary state in which the project is located.

22. Total Engineering Manhours – The total engineering manhours, including both direct and indirect, spent on the project. Direct hours may be taken from COEMIS, indirect from other sources.

23. Total Construction Manhours – The total construction manhours, including both direct and indirect, spent on the project.

at the midpoint of the construction phase. We assumed that the total construction amount was determined in the construction start year. Once the costs were assigned to specific years, they were converted into 1987 dollars using the 20-city annual average *Engineering News Record* (ENR) Construction Cost Index.

Finally, we made no adjustments for regional cost differences for four reasons: (1) USACE salaries are not regionally adjusted, (2) regional differences in construction labor costs are minimized by the requirements of the Davis-Bacon Act, (3) construction materials and equipment are frequently not purchased locally, and (4) the analysis of cost ratios — regional USACE costs divided by regional construction costs — rather than absolute costs reduces the effect of any regional variations.

TABLE A-2

PROJECT CATEGORY MAPPING FOR USACE CIVIL WORKS DATA CALL

Project category	Fund types
Channels and harbors	BA – 121 BB – 100,121,21X BE - 21X FW - 216
Locks and dams	BA - 220 BB - 22X BF - 220
Beach erosion control	BA - 140 BB - 410 BC - 400 BD - 140,4XX GM - 400
Flood control	BA - 151,510,511 BB - 230,516 BD - 516,517 BE - 150,151,5XX BG - 511 BJ - 517 FW - 511,516,517
Flood control reservoirs	BB - 520 BC - 520 BD - 520 BE - 152,52X BT - 520
Multipurpose power	BA - 600 BF - 100,160,6XX BK - 600

Note: Two-letter part of fund type is from COEMIS project identification code, 3-digit part of fund type is from civil works appropriation code, and X's refer to all numbers starting with digits shown (e g , 1XX = 100 – 199)

(Continued)

PROJECT CATEGORY MAPPING FOR USACE CIVIL WORKS DATA CALL (Continued)

Project category	Fund types
Rehabilitation – channels and harbors	BE - 300 BH - 800,813 BJ - 813
Rehabilitation – locks and dams	BH - 814,818 BP - 814
Operations and maintenance – channels and harbors	CA - 11X,211
Operations and maintenance – locks and dams	CA - 12X CB - 120
Operations and maintenance – flood control	CA - 100,300,510 CB - 20X,23X-29X
Operations and maintenance – flood control reservoirs	CB - 21X BH - 817 BP - 817
Operations and maintenance – multipurpose power	BH - 818 BP - 818 CC - 210,3XX,510 CG - 300
Operations and maintenance – channel and harbor improvements	CB - 22X CD - 220 CG - 232
Flood Control – rehabilitation	BH - 516,517 DC - 3XX
Flood control – construction	ER - 32X
Recreation	BG - 711,713,720,770

Note: Two-letter part of fund type is from COEMIS project identification code. 3-digit part of fund type is from civil works appropriation code, and X's refer to all numbers starting with digits shown (e g , 1XX = 100 - 199)

APPENDIX B

DESCRIPTIVE STATISTICS FOR COLLECTED DATA

DESCRIPTIVE STATISTICS FOR COLLECTED DATA

Cost ratios derived using the project costs collected from the civil works data call are shown in Tables B-1 through B-10. The definition of each ratio is noted in each table. For each of the 10 U.S. Army Corps of Engineers (USACE) cost ratios, the following information is displayed by project category:

- The sample size: number of valid projects reported

- The minimum value

- The 20th percentile: the value below which 20 percent of the sample project cost ratios fell

- The 40th percentile

- The median value: the 50th percentile

- The 60th percentile

- The 80th percentile

- The maximum value.

When the sample size is very small, several of these statistics may be the same. For example, if there is only one project in a given category, the minimum and maximum values will be identical (as will the intermediate percentiles).

The regression equations described in Chapter 2 provide point estimates for a typical project within each category. However, actual project costs can differ from those estimates and still be reasonable. USACE managers must use their judgement in deciding what the appropriate range should be for each cost ratio and project category. This range will depend upon the complexity of the project, factors unique to a specific district, and the distribution of actual costs for other projects. The descriptive statistics presented in this appendix can therefore be used as a valuable adjunct to the regression equations; they are not a substitute for those equations.

TABLE B-1

DISTRIBUTION OF USACE COST RATIOS FOR PLANNING

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	53	0.000	0.006	0.042	0.078	0.117	0.216	0.390
Locks/Dams	4	0.001	0.001	0.001	0.003	0.004	0.015	0.015
Beach Erosion	17	0.000	0.026	0.034	0.093	0.098	0.141	0.294
Flood Control	127	0.000	0.025	0.048	0.068	0.093	0.203	0.838
Flood Control - Reservoir	19	0.000	0.000	0.001	0.001	0.004	0.015	0.029
Multipurpose Power	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rehab - Channel Harbor	0	..	..	.	.	.	..	..
Rehab - Locks/Dams	0	..	.	..	..	.	..	..
O&M - Channel/Harbor	4	0.001	0.001	0.001	0.006	0.011	0.064	0.064
O&M - Locks/Dams	0	..	..	..	.	..	.	..
O&M - Flood Control	0	..	..	..	..	..	..	..
O&M - F C Reservoir	0	.	..	.	.	..	..	..
O&M - Multipurpose Power	0		.	.	..	..	..	..
O&M - C H Improvement	0	.	..	..	..	..	..	..
F C - Rehabilitation	19	0.007	0.038	0.075	0.090	0.120	0.152	0.233
F C - Construction	2	0.001	0.001	0.001	0.001	0.002	0.002	0.002
Recreation	2	0.035	0.035	0.035	0.065	0.095	0.095	0.095

Note: Ratios are planning costs divided by the construction contract amount

TABLE B-2

DISTRIBUTION OF USACE COST RATIOS FOR TOTAL ENGINEERING COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	112	0 001	0 043	0 070	0 093	0 116	0 252	4 261
Locks/Dams	23	0 026	0 035	0 059	0 110	0 147	0 218	0 287
Beach Erosion	37	0 015	0 044	0 082	0 105	0 113	0 165	3 172
Flood Control	240	0 005	0 072	0 138	0 170	0 210	0 312	1 896
Flood Control Reservoir	53	0 019	0 053	0 083	0 095	0 124	0 168	0 919
Multipurpose Power	22	0 018	0 065	0 104	0 113	0 122	0 166	0 253
Rehab Channel/Harbor	7	0 006	0 050	0 075	0 076	0 082	0 193	0 222
Rehab Locks/Dams	14	0 012	0 055	0 066	0 079	0 084	0 119	0 154
O&M Channel/Harbor	211	0 001	0 018	0 035	0 047	0 062	0 112	1 264
O&M Locks/Dams	13	0 027	0 028	0 028	0 029	0 030	0 033	0 272
O&M Flood Control	4	0 030	0 030	0 031	0 036	0 041	0 050	0 050
O&M F/C Reservoir	2	0 060	0 060	0 060	0 064	0 067	0 067	0 067
O&M Multipurpose Power	48	0 023	0 028	0 035	0 041	0 060	0 073	0 478
O&M C H Improvement	4	0 035	0 035	0 059	0 104	0 149	0 537	0 537
F C Rehabilitation	26	0 015	0 088	0 228	0 268	0 383	0 610	2 515
F C Construction	21	0 061	0 095	0 123	0 140	0 150	0 168	0 673
Recreation	22	0 029	0 040	0 040	0 040	0 047	0 109	1 356

Note: Ratios are total engineering costs divided by the construction contract amount

TABLE B-3

DISTRIBUTION OF USACE COST RATIOS FOR ARCHITECT/ENGINEER (AE) CONTRACT COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	61	0.000	0.003	0.012	0.019	0.024	0.058	0.890
Locks/Dams	22	0.001	0.004	0.007	0.012	0.018	0.024	0.038
Beach Erosion	11	0.004	0.005	0.012	0.023	0.025	0.030	1.814
Flood Control	99	0.000	0.004	0.008	0.016	0.021	0.066	0.669
Flood Control Reservoir	50	0.001	0.004	0.007	0.008	0.012	0.021	0.129
Multipurpose Power	21	0.000	0.003	0.005	0.007	0.012	0.020	0.062
Rehab Channel/Harbor	3	0.003	0.003	0.010	0.010	0.010	0.018	0.018
Rehab Locks/Dams	10	0.000	0.005	0.006	0.007	0.009	0.015	0.032
O&M Channel/Harbor	44	0.000	0.002	0.007	0.010	0.018	0.048	0.075
O&M Locks/Dams	1	0.003	0.003	0.003	0.003	0.003	0.003	0.003
O&M Flood Control	0	..	.		..	..	..	
O&M F/C Reservoir	1	0.004	0.004	0.004	0.004	0.004	0.004	0.004
O&M Multipurpose Power	5	0.004	0.007	0.012	0.014	0.114	0.238	0.262
O&M C/H Improvement	1	0.028	0.028	0.028	0.028	0.028	0.028	0.028
F/C Rehabilitation	8	0.014	0.020	0.024	0.028	0.032	0.045	0.250
F/C Construction	21	0.005	0.015	0.024	0.026	0.028	0.041	0.079
Recreation	5	0.007	0.010	0.027	0.041	0.062	0.084	0.086

Note: Ratios are AE contract amount divided by the construction contract amount

TABLE B-4

DISTRIBUTION OF USACE COST RATIOS FOR SUPERVISION AND REVIEW COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	24	0.000	0.000	0.001	0.001	0.003	0.006	0.061
Locks/Dams	22	0.000	0.000	0.001	0.001	0.001	0.004	0.010
Beach Erosion	9	0.000	0.000	0.001	0.002	0.002	0.006	0.067
Flood Control	58	0.000	0.000	0.001	0.001	0.002	0.012	0.261
Flood Control Reservoir	44	0.000	0.000	0.001	0.001	0.001	0.003	0.012
Multipurpose Power	18	0.000	0.000	0.001	0.001	0.001	0.004	0.018
Rehab Channel Harbor	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rehab Locks Dams	7	0.000	0.000	0.001	0.003	0.003	0.007	0.007
O&M Channel/Harbor	8	0.000	0.001	0.004	0.004	0.004	0.012	0.016
O&M Locks Dams	0	--	--	--	.	.	--	.
O&M Flood Control	0	--	--	--	.	--		.
O&M F C Reservoir	0	.	--	--	.	.		.
O&M Multipurpose Power	3	0.000	0.000	0.135	0.135	0.135	0.146	0.146
O&M C H improvement	.	0.002	0.002	0.002	0.002	0.002	0.002	0.002
F C Rehabilitation	3	0.001	0.001	0.001	0.001	0.001	0.255	0.055
F C Construction	20	0.001	0.002	0.003	0.004	0.004	0.005	0.012
Recreation	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005

Note: Ratios are supervision and review costs divided by the construction contract amount

TABLE B-5

DISTRIBUTION OF USACE COST RATIOS FOR DIRECT ENGINEERING AND DESIGN COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel Harbor	104	0 001	0 024	0 041	0 052	0 067	0 137	0 943
Locks Dams	23	0 020	0 027	0 045	0 048	0 056	0 085	0 096
Beach Erosion	37	0 004	0 022	0 045	0 057	0 072	0 108	1 355
Flood Control	231	0 000	0 045	0 080	0 113	0 138	0 199	1 032
Flood Control Reservoir	54	0 002	0 035	0 050	0 065	0 089	0 126	0 885
Multipurpose Power	22	0 016	0 038	0 064	0 077	0 086	0 092	1 143
Rehab Channel/Harbor	7	0 005	0 014	0 027	0 042	0 042	0 168	0 196
Rehab Locks Dams	14	0 009	0 033	0 040	0 063	0 075	0 082	0 112
O&M Channel/Harbor	198	0 000	0 012	0 028	0 038	0 050	0 085	080
O&M Locks Dams	1	0 238	0 238	0 238	0 238	0 238	0 238	0 238
O&M Flood Control	8	0 018	0 018	0 019	0 021	0 024	0 030	0 056
O&M F/C Reservoir	2	0 036	0 036	0 036	0 050	0 064	0 064	0 064
O&M Multipurpose Power	26	0 028	0 036	0 037	0 039	0 044	0 052	0 184
O&M C/H Improvement	4	0 018	0 018	0 021	0 066	0 110	0 326	0 326
F C Rehabilitation	26	0 008	0 060	0 148	0 169	0 180	0 316	1 309
F/C Construction	21	0 028	0 044	0 052	0 064	0 072	0 106	0 412
Recreation	26	0 017	0 024	0 024	0 025	0 028	0 048	298

Note: Ratios are direct engineering and design costs divided by the construction contract amount

TABLE B-6

DISTRIBUTION OF USACE COST RATIOS FOR TECHNICAL INDIRECT COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel Harbor	30	0.000	0.001	0.005	0.009	0.011	0.028	0.330
Locks Dams	19	0.003	0.007	0.013	0.014	0.015	0.023	0.073
Beach Erosion	35	0.000	0.004	0.007	0.009	0.013	0.022	0.117
Flood Control	205	0.000	0.009	0.020	0.026	0.030	0.051	0.955
Flood Control Reservoir	40	0.000	0.003	0.010	0.011	0.012	0.024	0.061
Multipurpose Power	21	0.000	0.002	0.004	0.005	0.010	0.010	0.052
Rehab Channel Harbor	7	0.001	0.002	0.004	0.004	0.007	0.015	0.023
Rehab Locks Dams	11	0.003	0.008	0.013	0.013	0.014	0.021	0.033
O&M Channel Harbor	198	0.000	0.003	0.006	0.008	0.010	0.019	0.166
O&M Locks Dams	1	0.031	0.031	0.031	0.031	0.031	0.031	0.031
O&M Flood Control	8	0.012	0.012	0.012	0.014	0.016	0.020	0.037
O&M F-C Reservoir	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
O&M Multipurpose Power	25	0.002	0.020	0.024	0.024	0.025	0.030	0.036
O&M C H Improvement	4	0.002	0.002	0.014	0.023	0.032	0.039	0.039
F-C Rehabilitation	13	0.001	0.004	0.014	0.024	0.030	0.075	0.194
F-C Construction	19	0.012	0.019	0.024	0.029	0.034	0.041	0.110
Recreation	26	0.001	0.016	0.016	0.016	0.016	0.019	0.022

Note: Ratios are technical indirect costs divided by the construction contract amount

TABLE B-7

DISTRIBUTION OF USACE COST RATIOS FOR SUPERVISION AND ADMINISTRATION COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	107	0.001	0.023	0.040	0.055	0.063	0.096	0.735
Locks Dams	23	0.026	0.032	0.047	0.048	0.052	0.065	0.082
Beach Erosion	37	0.008	0.029	0.039	0.043	0.053	0.062	0.179
Flood Control	228	0.001	0.031	0.047	0.056	0.065	0.100	0.511
Flood Control Reservoir	54	0.014	0.030	0.038	0.042	0.047	0.062	0.095
Multipurpose Power	22	0.003	0.019	0.023	0.033	0.036	0.043	0.089
Rehab Channel/Harbor	7	0.015	0.015	0.027	0.033	0.086	0.104	0.166
Rehab Locks Dams	14	0.019	0.034	0.047	0.053	0.067	0.097	0.139
O&M Channel Harbor	215	0.000	0.026	0.048	0.057	0.064	0.090	0.318
O&M Locks Dams	13	0.053	0.055	0.056	0.056	0.059	0.063	0.148
O&M Flood Control	8	0.045	0.045	0.050	0.052	0.053	0.056	0.057
O&M F C Reservoir	2	0.056	0.056	0.056	0.057	0.057	0.057	0.057
O&M Multipurpose Power	51	0.018	0.052	0.057	0.058	0.060	0.067	0.302
O&M C H Improvement	4	0.049	0.049	0.060	0.066	0.073	0.163	0.163
F C Rehabilitation	21	0.009	0.017	0.035	0.040	0.060	0.071	0.152
F C Construction	21	0.036	0.060	0.066	0.067	0.071	0.076	0.167
Recreation	25	0.020	0.050	0.053	0.055	0.057	0.058	0.086

Note: Ratios are supervision and administration costs divided by the construction contract amount

TABLE B-8

DISTRIBUTION OF USACE COST RATIOS FOR SUPERVISION AND INSPECTION COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	93	0.001	0.021	0.073	0.044	0.048	0.071	1.728
Locks/Dams	23	0.015	0.022	0.033	0.041	0.048	0.065	0.082
Beach Erosion	36	0.004	0.022	0.034	0.035	0.039	0.053	0.179
Flood Control	225	0.001	0.023	0.037	0.044	0.050	0.086	0.442
Flood Control Reservoir	50	0.001	0.021	0.027	0.032	0.037	0.045	0.070
Multipurpose Power	22	0.009	0.017	0.020	0.025	0.031	0.038	0.065
Rehab Channel/Harbor	7	0.010	0.012	0.023	0.031	0.067	0.082	0.160
Rehab Locks/Dams	14	0.017	0.028	0.036	0.040	0.044	0.075	0.115
O&M Channel/Harbor	159	0.003	0.033	0.047	0.053	0.061	0.089	0.298
O&M Locks/Dams	13	0.045	0.047	0.048	0.048	0.050	0.053	0.133
O&M Flood Control	8	0.036	0.036	0.040	0.041	0.043	0.045	0.045
O&M F C Reservoir	1	0.045	0.045	0.045	0.045	0.045	0.045	0.045
O&M Multipurpose Power	51	0.015	0.043	0.046	0.047	0.048	0.057	0.259
O&M C/H Improvement	4	0.040	0.040	0.048	0.056	0.063	0.128	0.128
F C Rehabilitation	21	0.008	0.017	0.030	0.040	0.047	0.069	0.121
F C Construction	21	0.033	0.049	0.055	0.055	0.055	0.056	0.064
Recreation	25	0.016	0.040	0.042	0.044	0.046	0.046	0.081

Note: Ratios are supervision and inspection costs divided by the construction contract amount

TABLE B-9

DISTRIBUTION OF USACE COST RATIOS FOR GENERAL AND ADMINISTRATIVE COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel Harbor	99	0.000	0.005	0.014	0.018	0.025	0.044	0.992
Locks Dams	23	0.006	0.010	0.012	0.012	0.014	0.018	0.034
Beach Erosion	37	0.005	0.010	0.016	0.022	0.026	0.040	0.147
Flood Control	227	0.000	0.014	0.025	0.030	0.035	0.060	0.275
Flood Control Reservoir	53	0.000	0.012	0.017	0.018	0.023	0.030	0.108
Multipurpose Power	21	0.000	0.007	0.012	0.013	0.016	0.016	0.026
Rehab Channel/Harbor	7	0.001	0.006	0.008	0.010	0.028	0.032	0.049
Rehab Locks Dams	14	0.005	0.010	0.014	0.019	0.023	0.030	0.034
O&M Channel/Harbor	159	0.003	0.010	0.016	0.018	0.022	0.035	0.253
O&M Locks Dams	13	0.016	0.016	0.017	0.017	0.018	0.019	0.057
O&M Flood Control	8	0.009	0.009	0.010	0.010	0.011	0.011	0.012
O&M F C Reservoir	1	0.012	0.012	0.012	0.012	0.012	0.012	0.012
O&M Multipurpose Power	51	0.007	0.012	0.014	0.015	0.017	0.021	0.245
O&M C H Improvement	4	0.012	0.012	0.012	0.028	0.045	0.087	0.087
F C Rehabilitation	26	0.003	0.012	0.021	0.027	0.031	0.040	0.291
F C Construction	21	0.006	0.011	0.014	0.014	0.017	0.025	0.116
Recreation	26	0.010	0.011	0.011	0.012	0.012	0.013	0.043

Note: Ratios are general and administrative costs divided by the construction contract amount

TABLE B-10

DISTRIBUTION OF USACE COST RATIOS FOR AREA OFFICE OVERHEAD COSTS

Project category	Sample	Percentiles						
		Minimum	20th	40th	Median	60th	80th	Maximum
Channel/Harbor	32	0.000	0.000	0.001	0.001	0.002	0.004	0.013
Locks/Dams	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Beach Erosion	9	0.000	0.000	0.002	0.003	0.004	0.008	0.040
Flood Control	47	0.000	0.000	0.003	0.004	0.005	0.008	0.032
Flood Control Reservoir	12	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Multipurpose Power	10	0.000	0.000	0.001	0.002	0.002	0.005	0.011
Rehab Channel Harbor	5	0.000	0.001	0.002	0.002	0.002	0.003	0.003
Rehab Locks/Dams	1	0.004	0.004	0.004	0.004	0.004	0.004	0.004
O&M Channel Harbor	51	0.000	0.003	0.006	0.007	0.007	0.012	0.057
O&M Locks/Dams	1	0.041	0.041	0.041	0.041	0.041	0.041	0.041
O&M Flood Control	0	..	..	..	..	..	..	..
O&M F/C Reservoir	0	..	..	..	..	..	..	..
O&M Multipurpose Power	3	0.002	0.002	0.006	0.006	0.006	0.016	0.016
O&M C/H Improvement	0	..	..	..	..	..	..	..
F C Rehabilitation	3	0.001	0.001	0.001	0.001	0.001	0.001	0.001
F C Construction	2	0.005	0.005	0.005	0.021	0.036	0.036	0.036
Recreation	0	..	.	.	..	.		..

Note: Ratios area office overhead costs divided by the construction contract amount

APPENDIX C

CIVIL WORKS COST CURVES

APPENDIX C

CIVIL WORKS COST CURVES

This appendix contains curves which present the cost equations developed from the regression analyses. Cost equations, regression statistics, and graphic representations are presented for each category and cost analyzed. These curves display the characteristics of the derived cost equation — economies of scale, etc. — and can be used to estimate costs graphically, although calculations using the provided equations will yield more accurate results.

Users of these curves are reminded of the civil works cost estimating model that will perform estimating calculations and compare actual cost data to historic U.S. Army Corps of Engineers (USACE) cost experience. Further information on this model is contained in the civil works cost estimating model user's guide.

Total
engineering
costs
($000,000)

Construction contract amount ($000,000)
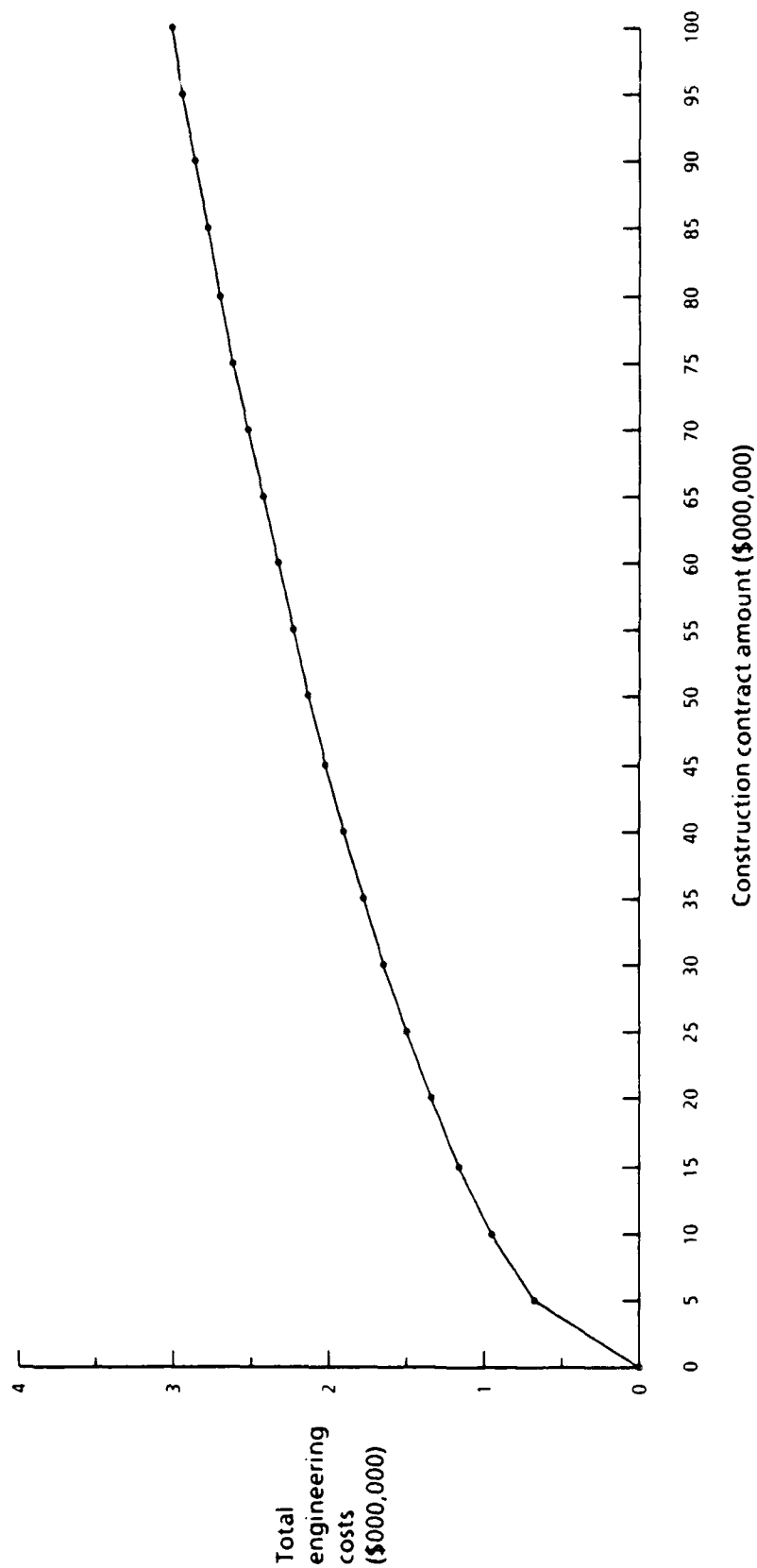
**Notes:** Total engineering costs = 301 * (Square root of construction contract amount)

(t = 11 3) (Adjusted R-Square = 0 62)

FIG. C-1. TOTAL ENGINEERING COSTS FOR CHANNEL/HARBOR PROJECTS

FIG. C-2. DIRECT E&D COSTS FOR CHANNEL/HARBOR PROJECTS
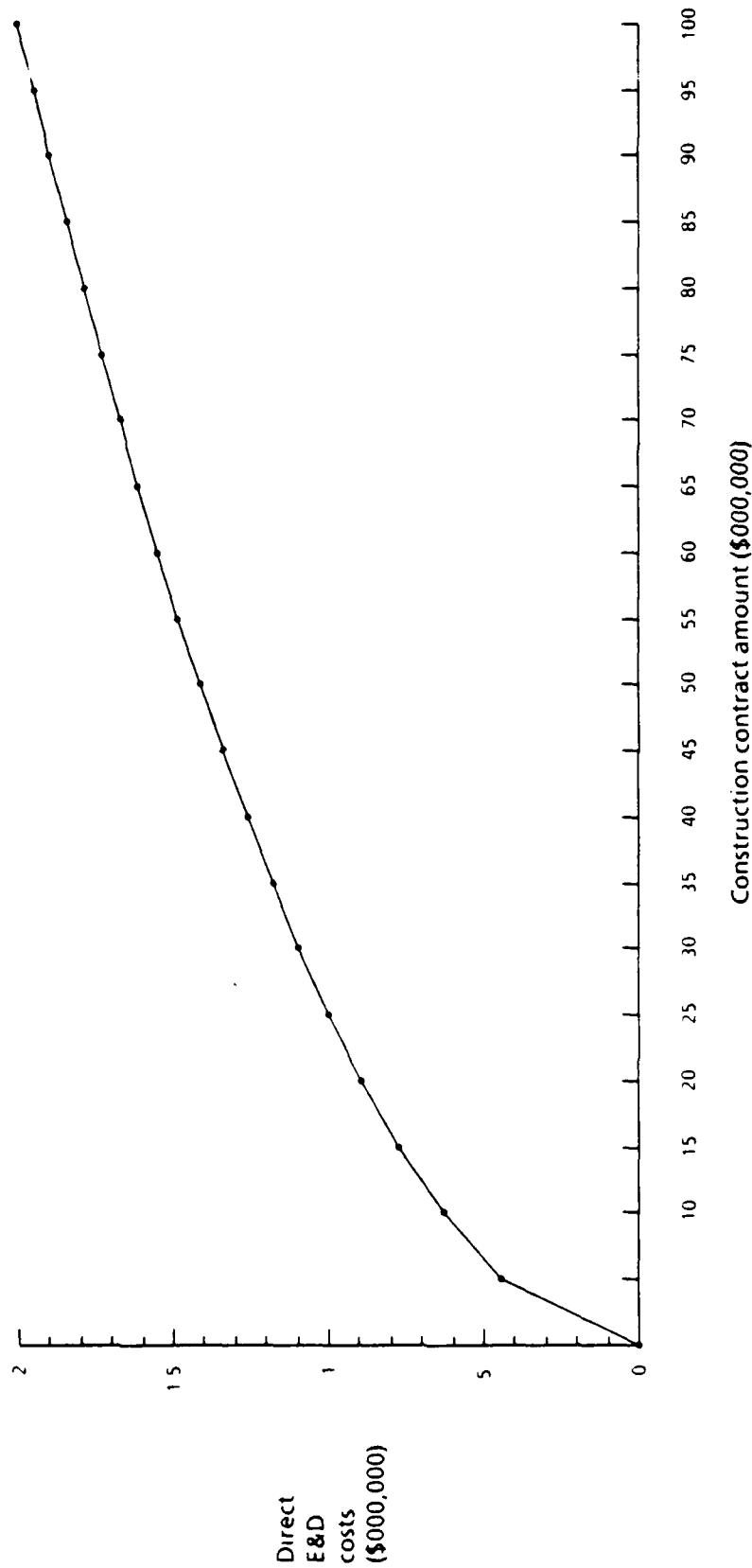
Notes: Direct E&D costs = 200 * [Square root of construction contract amount]
(t = 14.0) (Adjusted R-Square = 0.72)

Technical
Indirect
costs
($000,000)

Construction contract amount ($000,000)
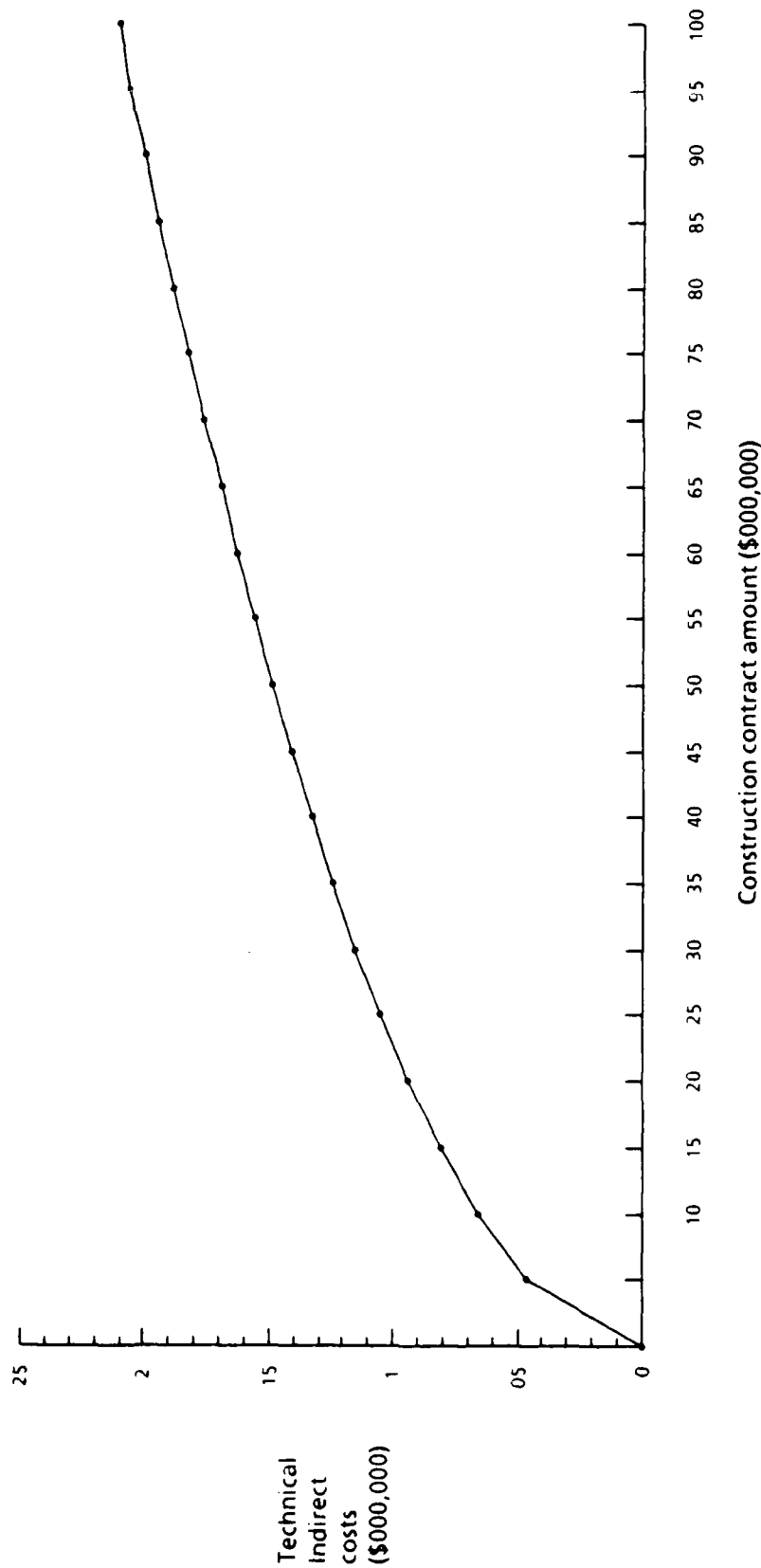
Notes: Technical indirect costs = 21 * [Square root of construction contract amount]
(t = 5 6)   (Adjusted R-Square = 0 28)

FIG. C-3. TECHNICAL INDIRECT COSTS FOR CHANNEL/HARBOR PROJECTS
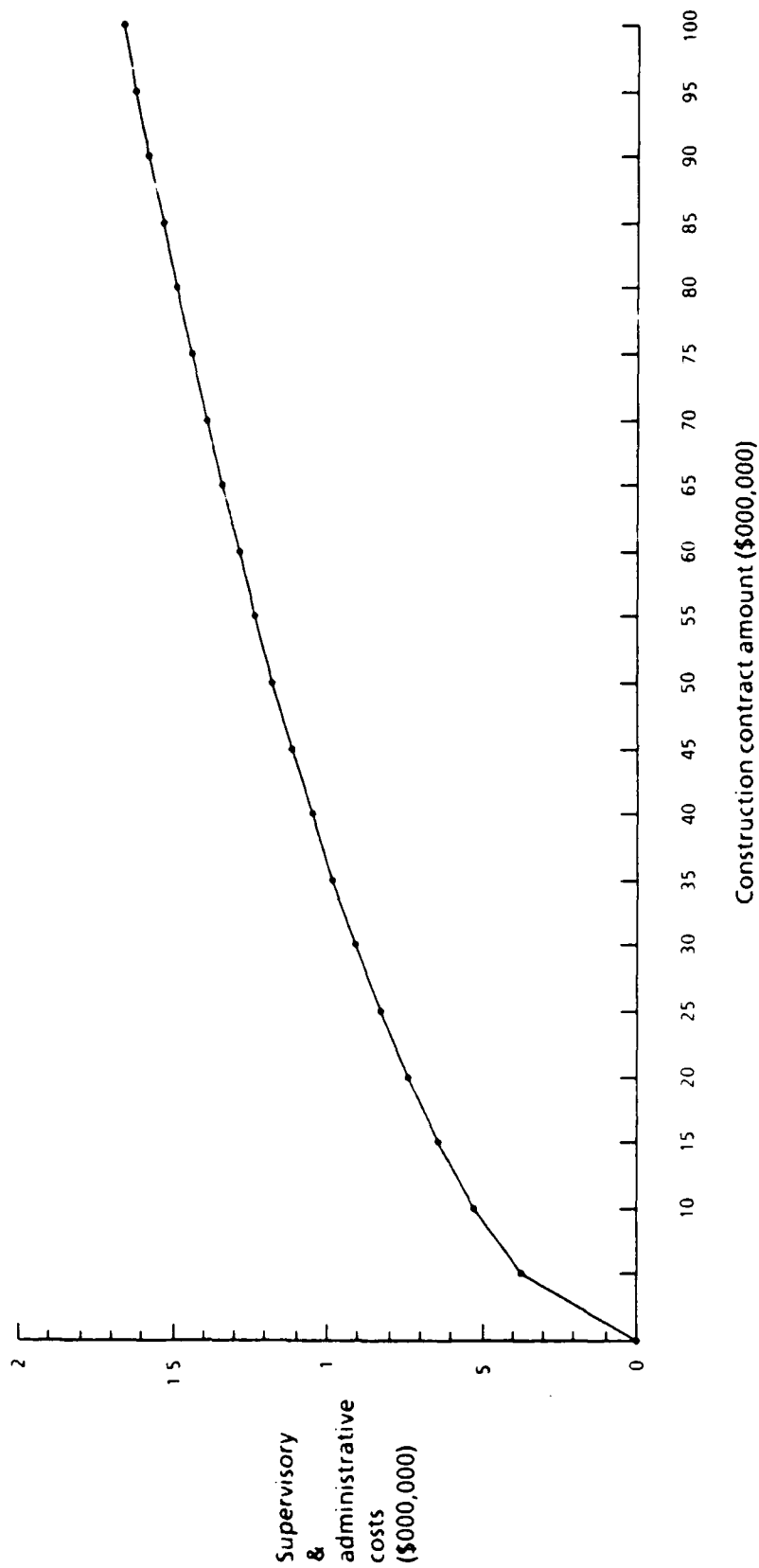
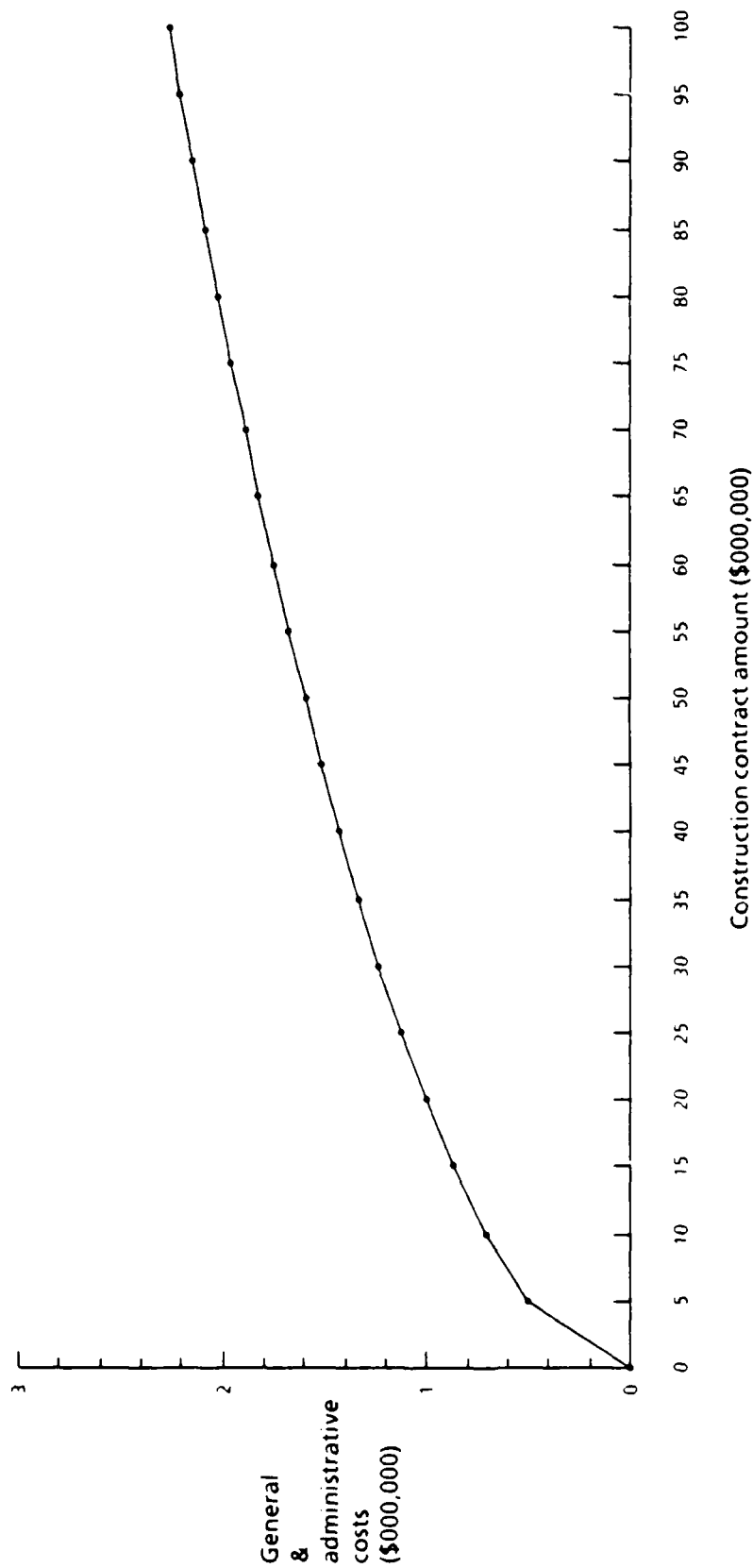**Notes:** Supervisory & administrative costs = 166 * (Square root of construction contract amount)

(t = 15 2)   (Adjusted R Square = 0 75)

FIG. C-4. SUPERVISORY & ADMINISTRATIVE COSTS FOR CHANNEL/HARBOR PROJECTS

Supervisory & inspection costs ($000,000)

Construction contract amount ($000,000)
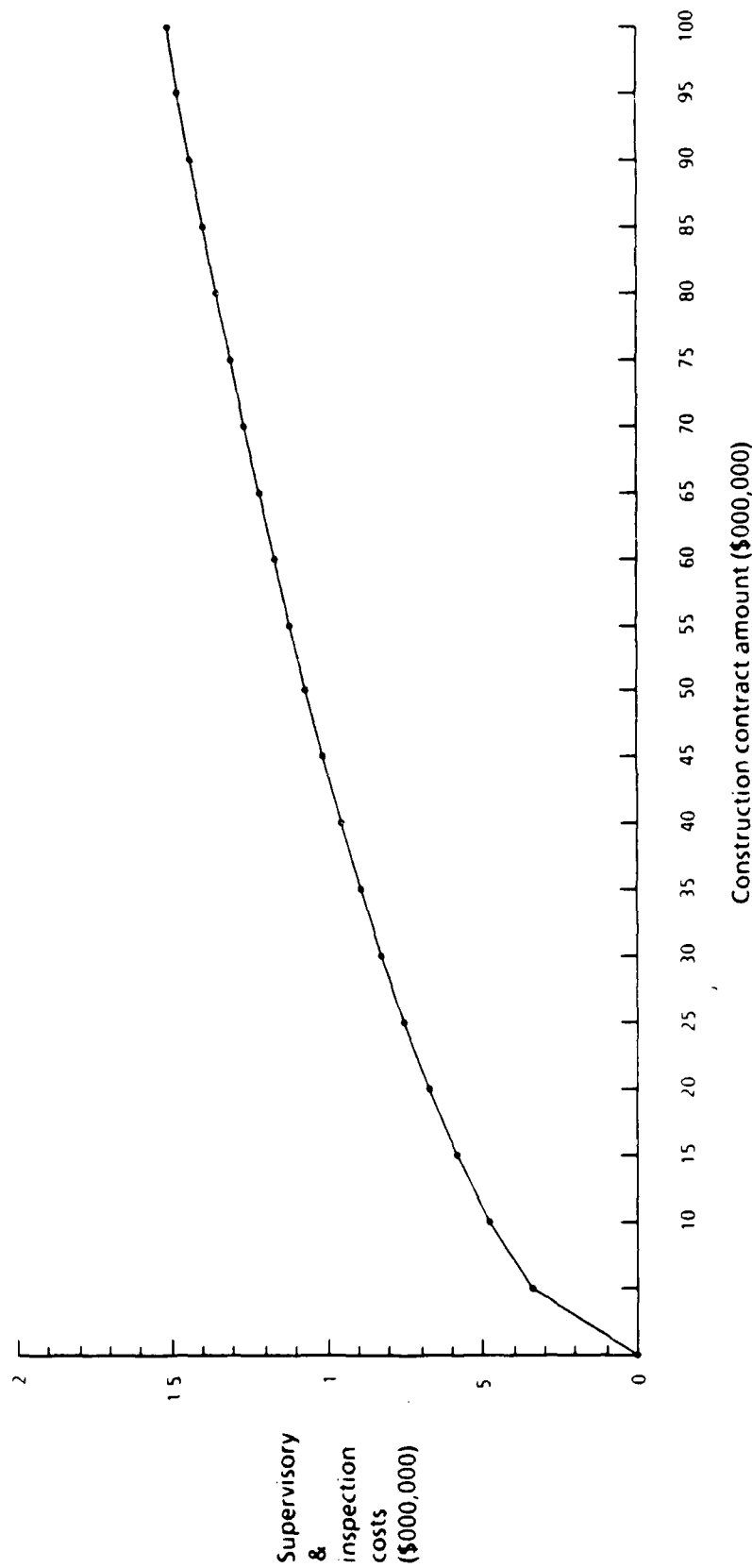
Notes: Supervisory & inspection costs = 151 * (Square root of construction contract amount)
(t = 14 8)   (Adjusted R·Square = 0 74)

FIG. C-5. SUPERVISORY & INSPECTION C STS FOR CHANNEL/HARBOR PROJECTS

General & administrative costs ($000,000)

Construction contract amount ($000,000)
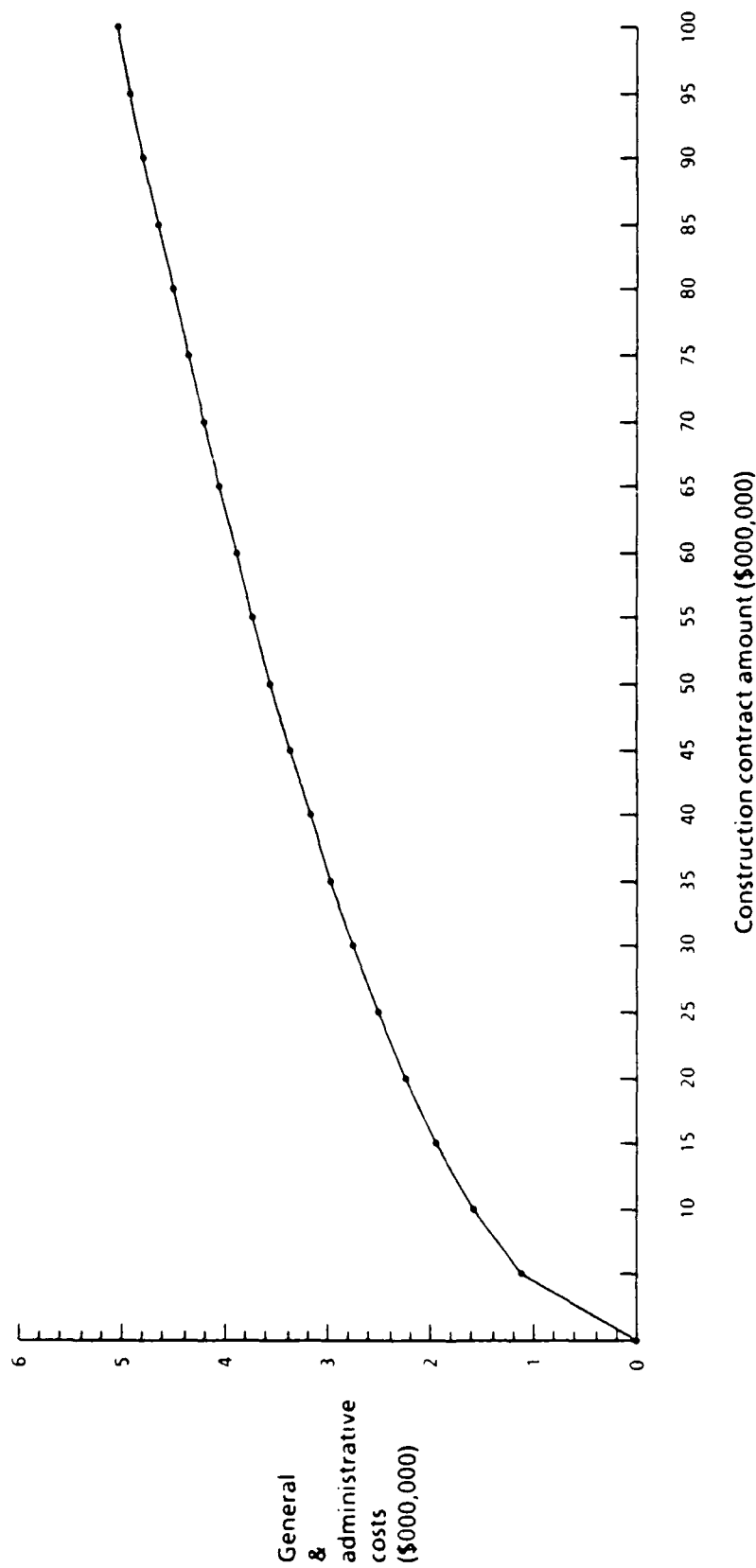
Notes: General & administrative costs = 50 * [Square root of construction contract amount]
(t = 8 4)   (Adjusted R-Square = 0 48)

FIG. C-6. GENERAL & ADMINISTRATIVE COSTS FOR CHANNEL/HARBOR PROJECTS

Total
engineering
costs
($000,000)

Construction contract amount ($000,000)

10 15 20 25 30 35 40 45 50 55 60 65 7(75 80 8 90 95 100
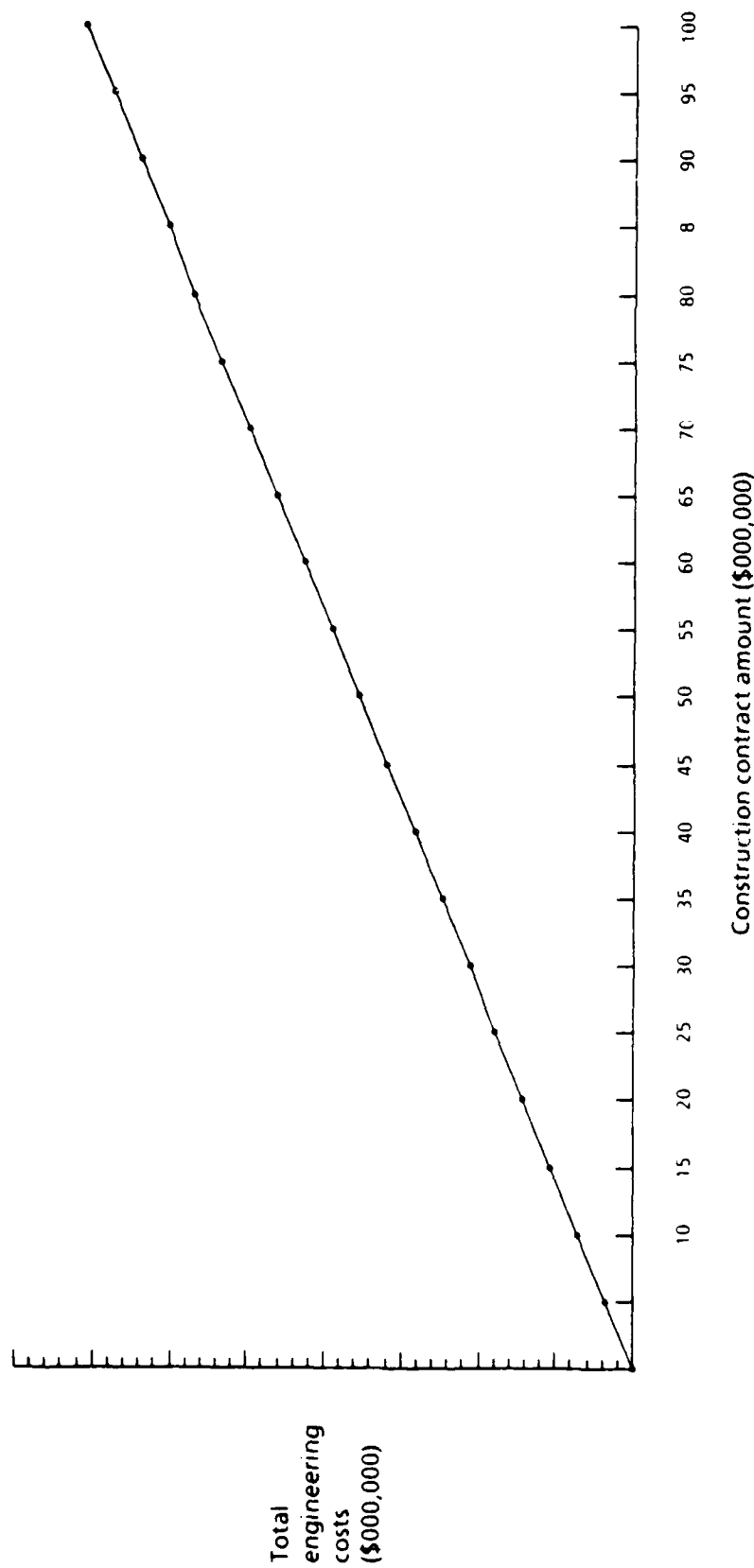
Notes: Total engineering costs = 0 071 * [Construction contract amount]
(t = 13 7)   (Adjusted R Square = 0 54)

FIG. C-7. TOTAL ENGINEERING COSTS FOR O&M: CHANNEL/HARBOR PROJECTS, REHAB: CHANNEL/HARBOR PROJECTS, AND O&M: CHANNEL/HARBOR IMPROVEMENT PROJECTS
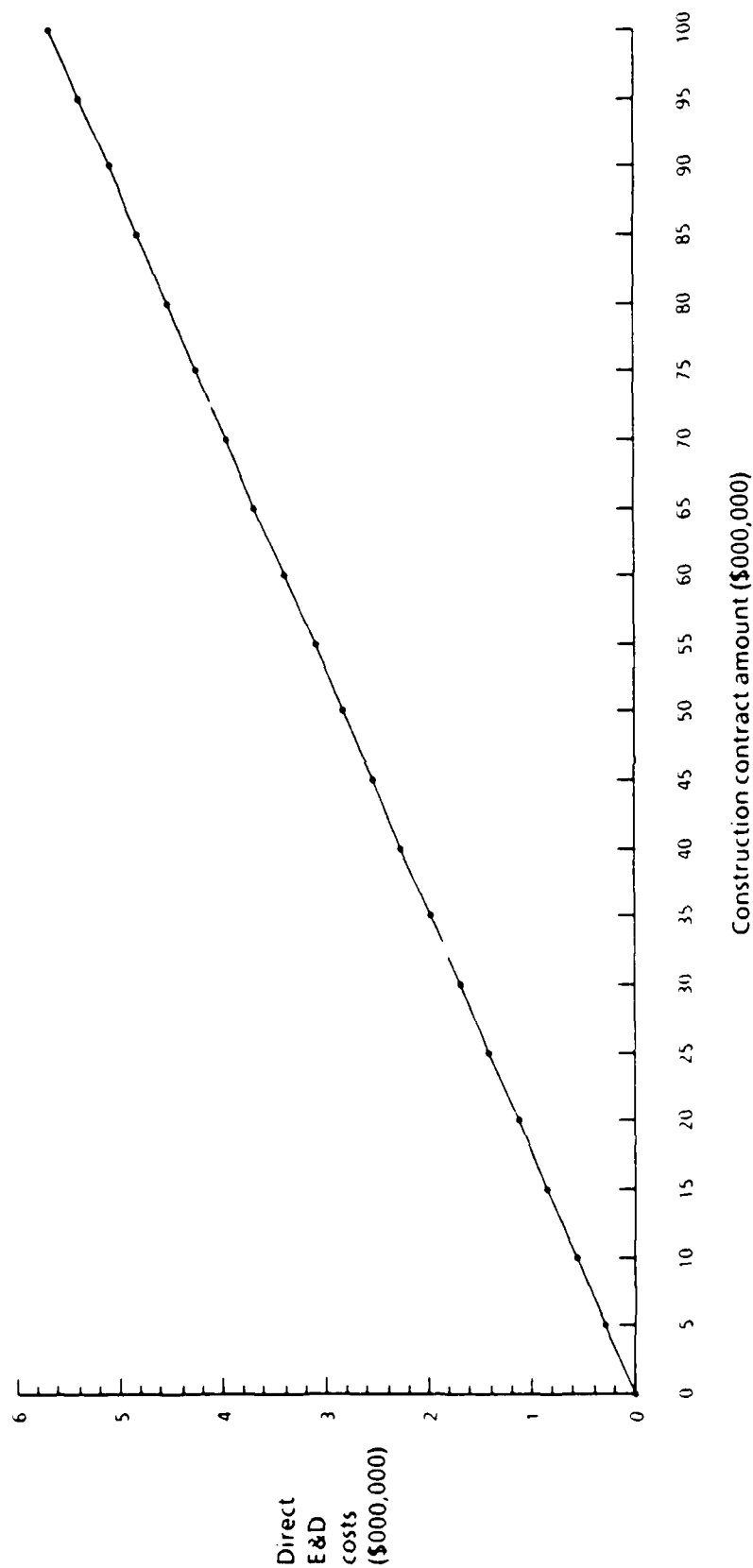
Notes: Direct E&D costs = 0.056 * [Construction contract amount]
(t = 12.4) (Adjusted R Square = 0.50)

FIG. C-8. DIRECT E&D COSTS FOR O&M: CHANNEL/HARBOR PROJECTS, REHAB: CHANNEL/HARBOR PROJECTS, AND O&M: CHANNEL/HARBOR IMPROVEMENT PROJECTS
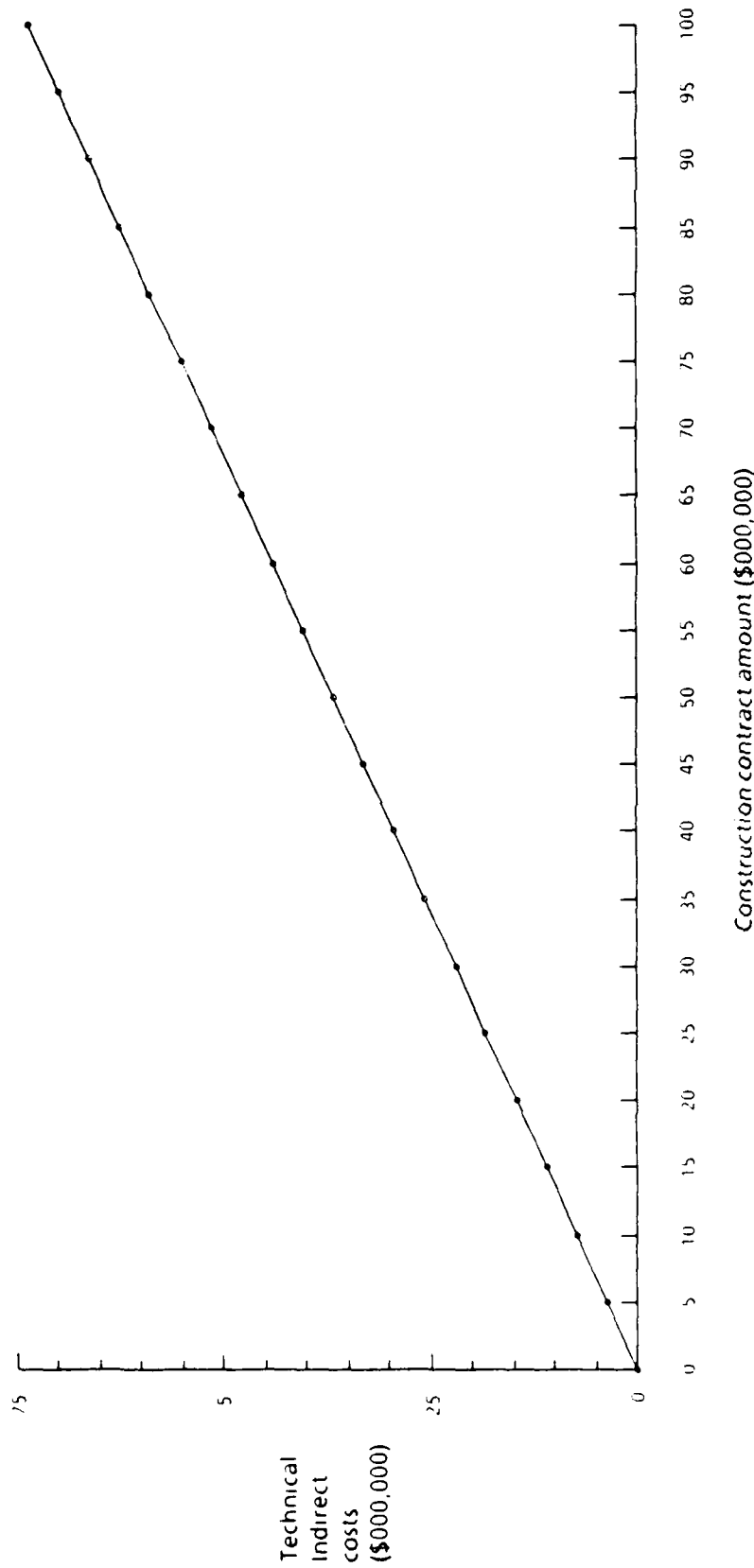
Notes Technical indirect costs = 0.007 • [Construction contract amount]
(1 − 10 5)   (Adjusted R-Square − 0.41)

FIG. C-9. TECHNICAL INDIRECT COSTS FOR O&M: CHANNEL/HARBOR PROJECTS, REHAB: CHANNEL/HARBOR PROJECTS, AND O&M: CHANNEL/HARBOR IMPROVEMENT PROJECTS
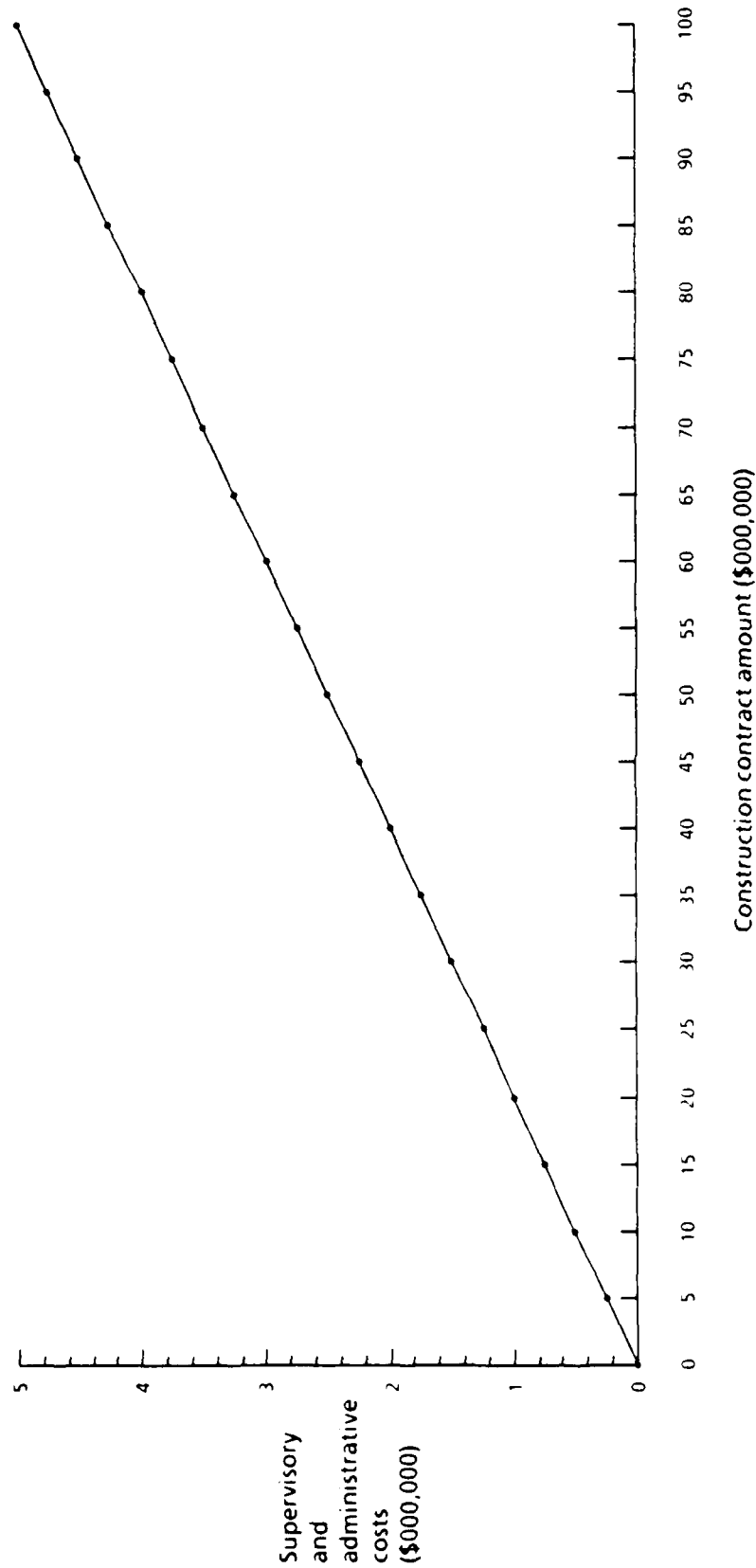
Notes: Supervisory & administrative costs = 0 050 * [Construction contract amount]
(t = 21.2)   (Adjusted R-Square = 0.74)

FIG. C-10. SUPERVISORY & ADMINISTRATION COSTS FOR O&M: CHANNEL/HARBOR PROJECTS, REHAB: CHANNEL/HARBOR PROJECTS, AND O&M: CHANNEL/HARBOR IMPROVEMENT PROJECTS

Construction contract amount ($000,000)

Supervisory
and
inspection
costs
($000,000)
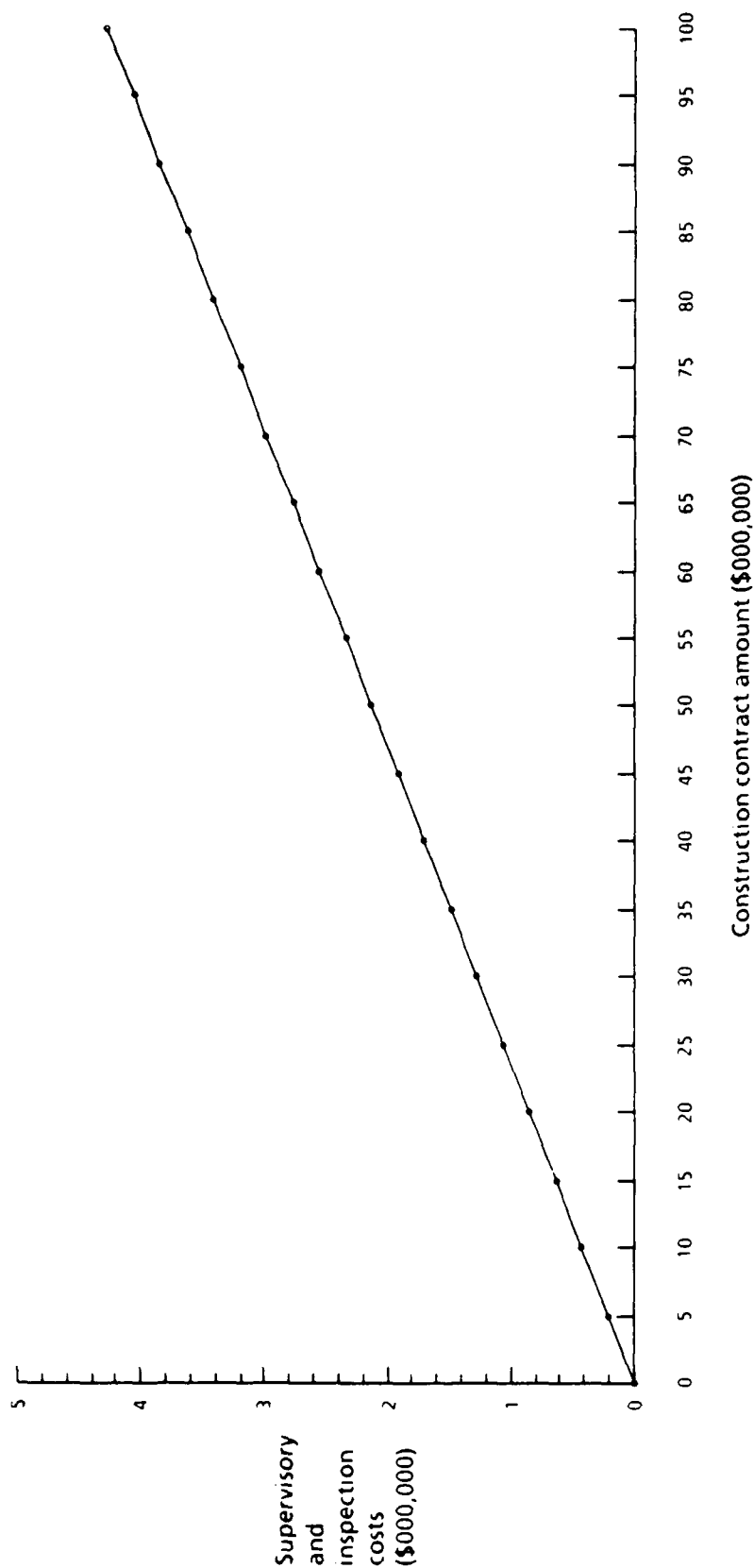
Notes: Supervisory & Inspection Costs = 0 043 * |Construction contract amount|
(t = 20 5)   (Adjusted R Square = 0 73)

FIG. C-11. SUPERVISORY & INSPECTION COSTS FOR O&M: CHANNEL/HARBOR PROJECTS, REHAB: CHANNEL/HARBOR PROJECTS, AND O&M: CHANNEL/HARBOR IMPROVEMENT PROJECTS

General and administrative costs ($000,000)

Construction contract amount ($000,000)
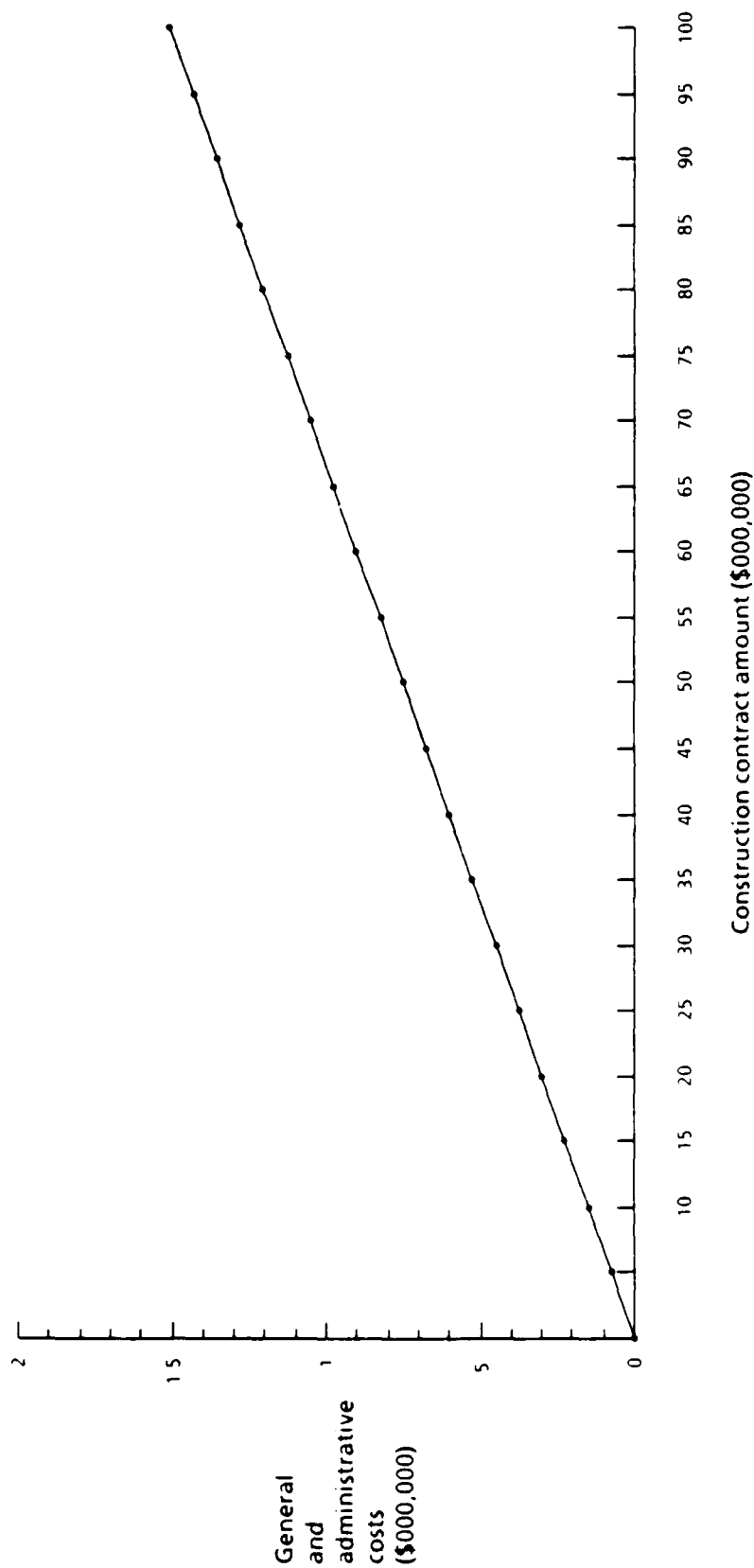
Notes: General & administrative costs = 0 015 * [Construction contract amount]
(t = 10 7)   (Adjusted R Square = 0 42)

FIG. C-12. GENERAL & ADMINISTRATIVE COSTS FOR O&M: CHANNEL/HARBOR PROJECTS, REHAB: CHANNEL/HARBOR PROJECTS, AND O&M: CHANNEL/HARBOR IMPROVEMENT PROJECTS
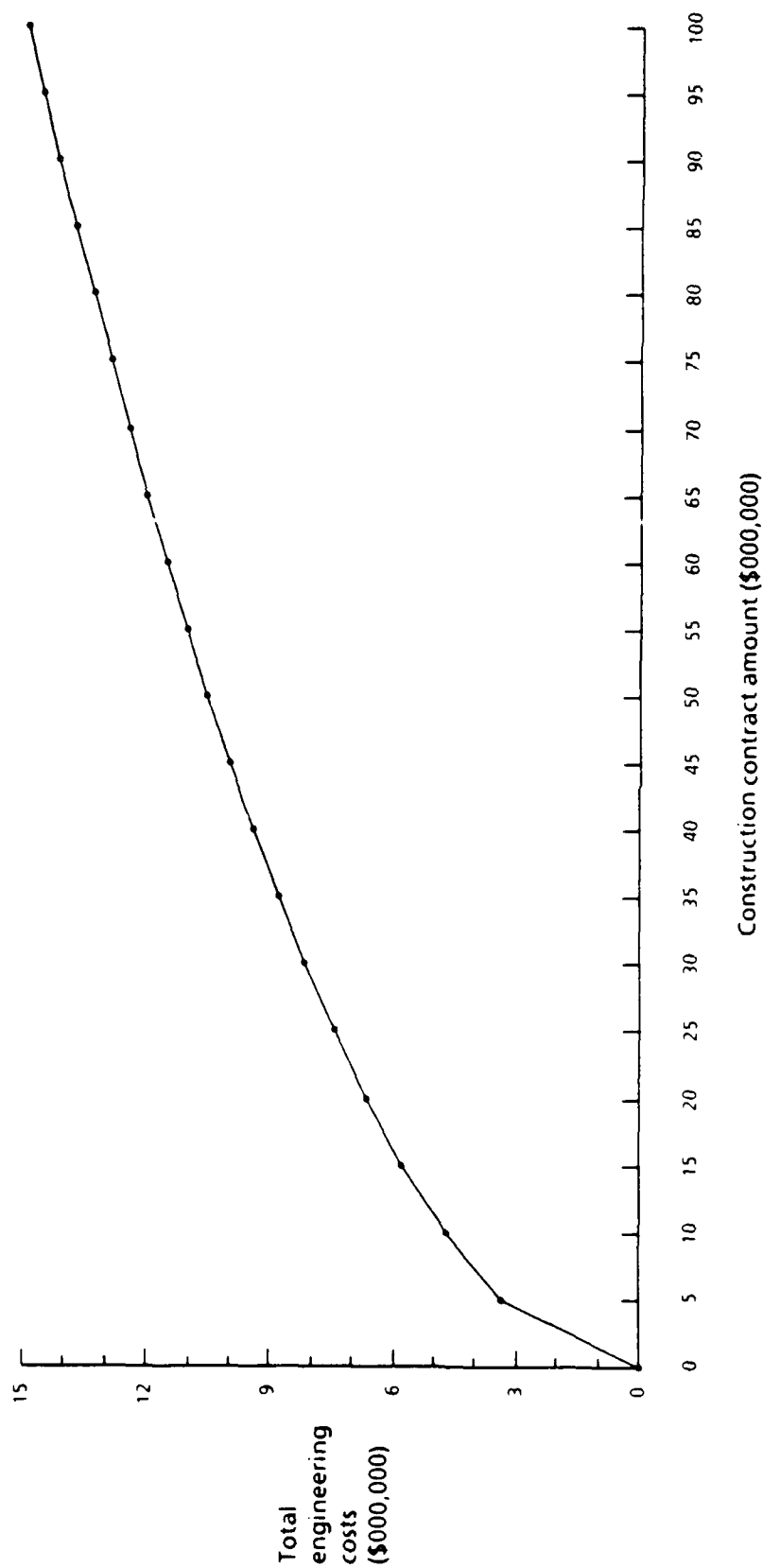
Notes: Total engineering costs = 1489 * [Square root of construction contract amount]
(t = 8 3)   (Adjusted R-Square = 0 66)

FIG. C-13. TOTAL ENGINEERING COSTS FOR LOCKS/DAMS PROJECTS, O&M: LOCKS/DAMS PROJECTS, AND REHAB: LOCKS/DAMS PROJECTS

Direct
E&D
costs
($000,000)

Construction contract amount ($000,000)
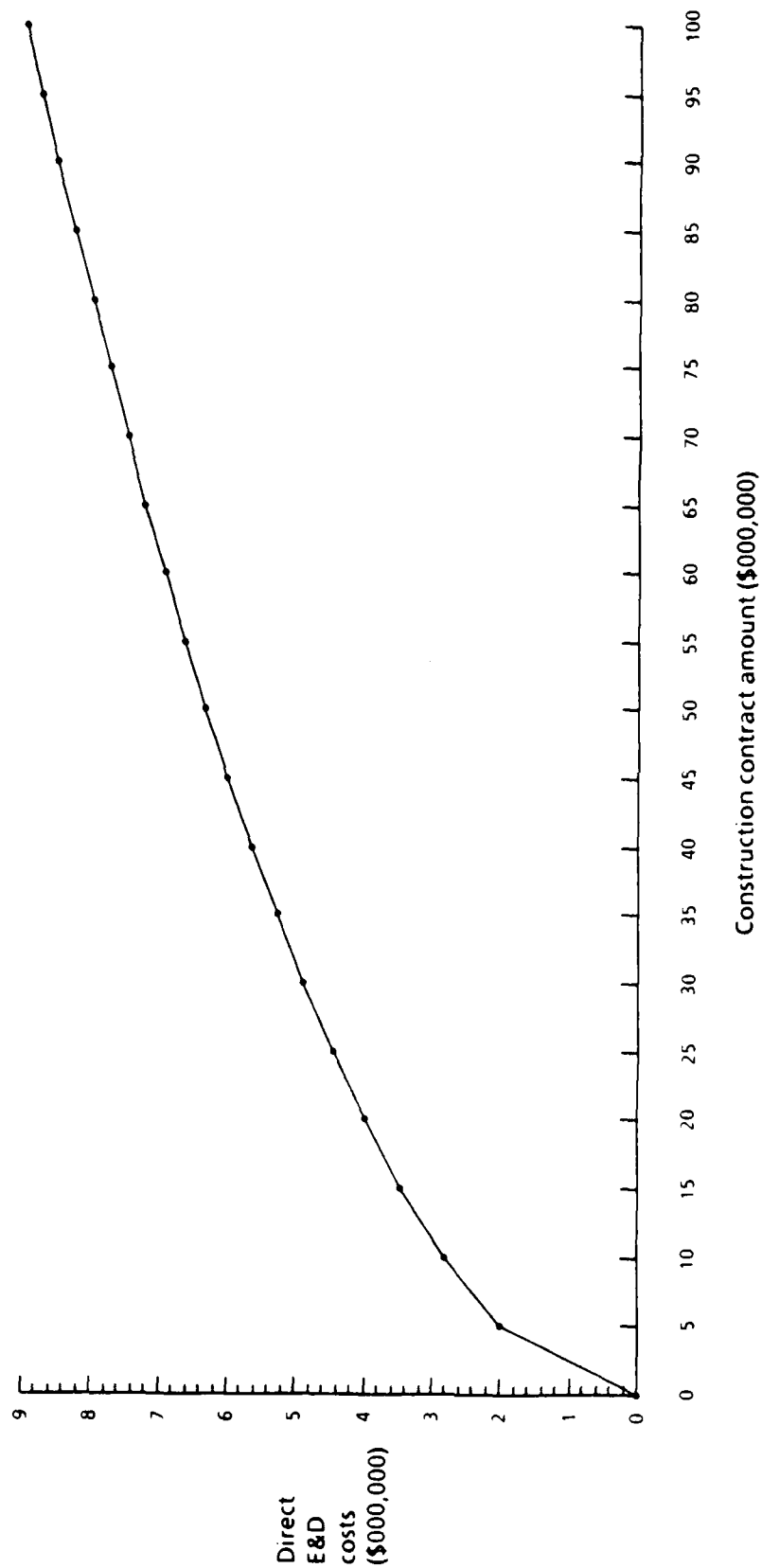
Notes: Direct E&D costs = 893 * [Square root of construction contract amount]
(t = 13 8)   (Adjusted R Square = 0 84)

FIG. C-14. DIRECT E&D COSTS FOR LOCKS/DAMS PROJECTS, O&M: LOCKS/DAMS PROJECTS, AND REHAB: LOCKS/DAMS PROJECTS

Technical
Indirect
costs
($000,000)

Construction contract amount ($000,000)
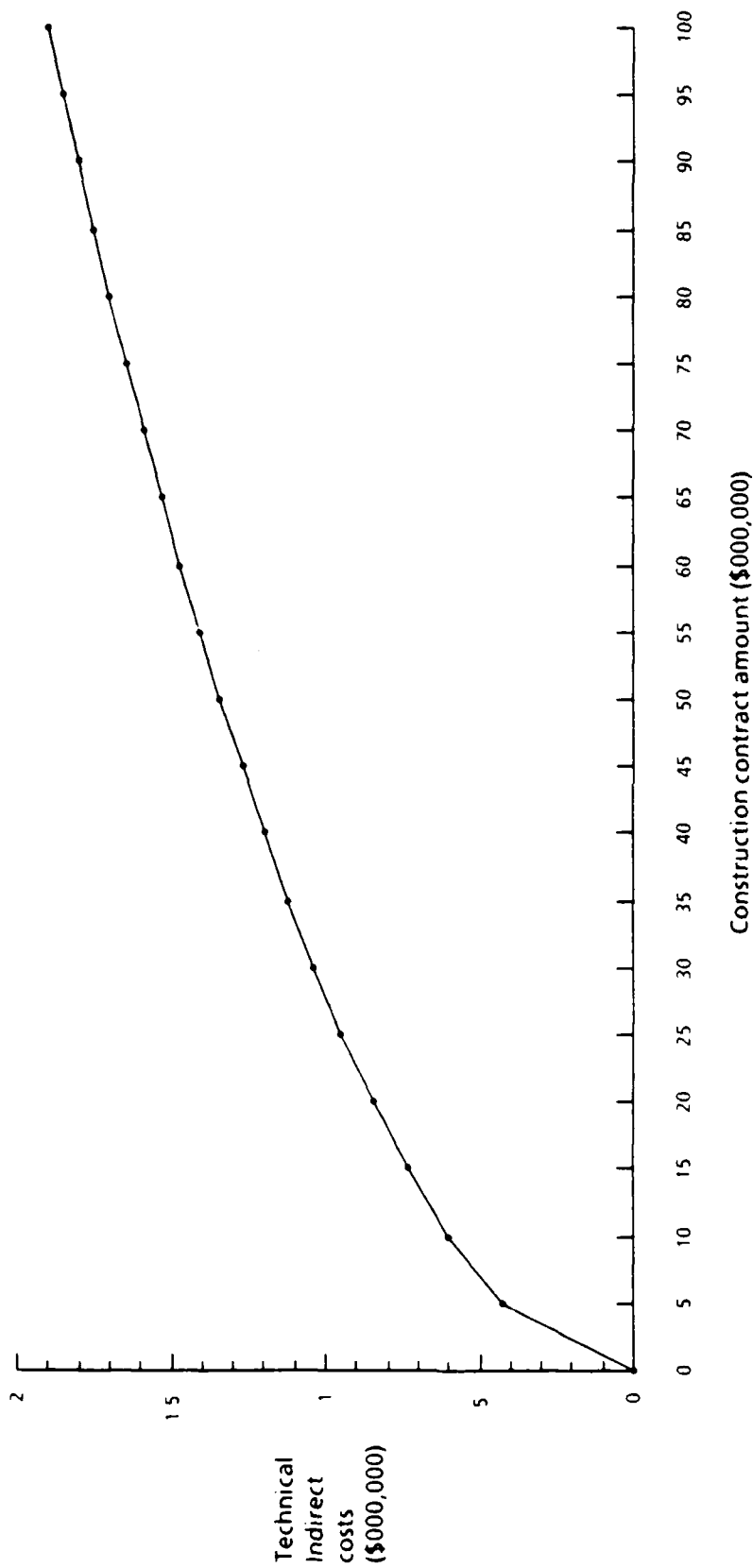
Notes: Technical indirect costs = 190 * [Square root of construction contract amount]
(t = 6 7)   (Adjusted R-Square = 0 56)

FIG. C-15. TECHNICAL INDIRECT COSTS FOR LOCKS/DAMS PROJECTS, O&M: LOCKS/DAMS PROJECTS, AND REHAB: LOCKS/DAMS PROJECTS
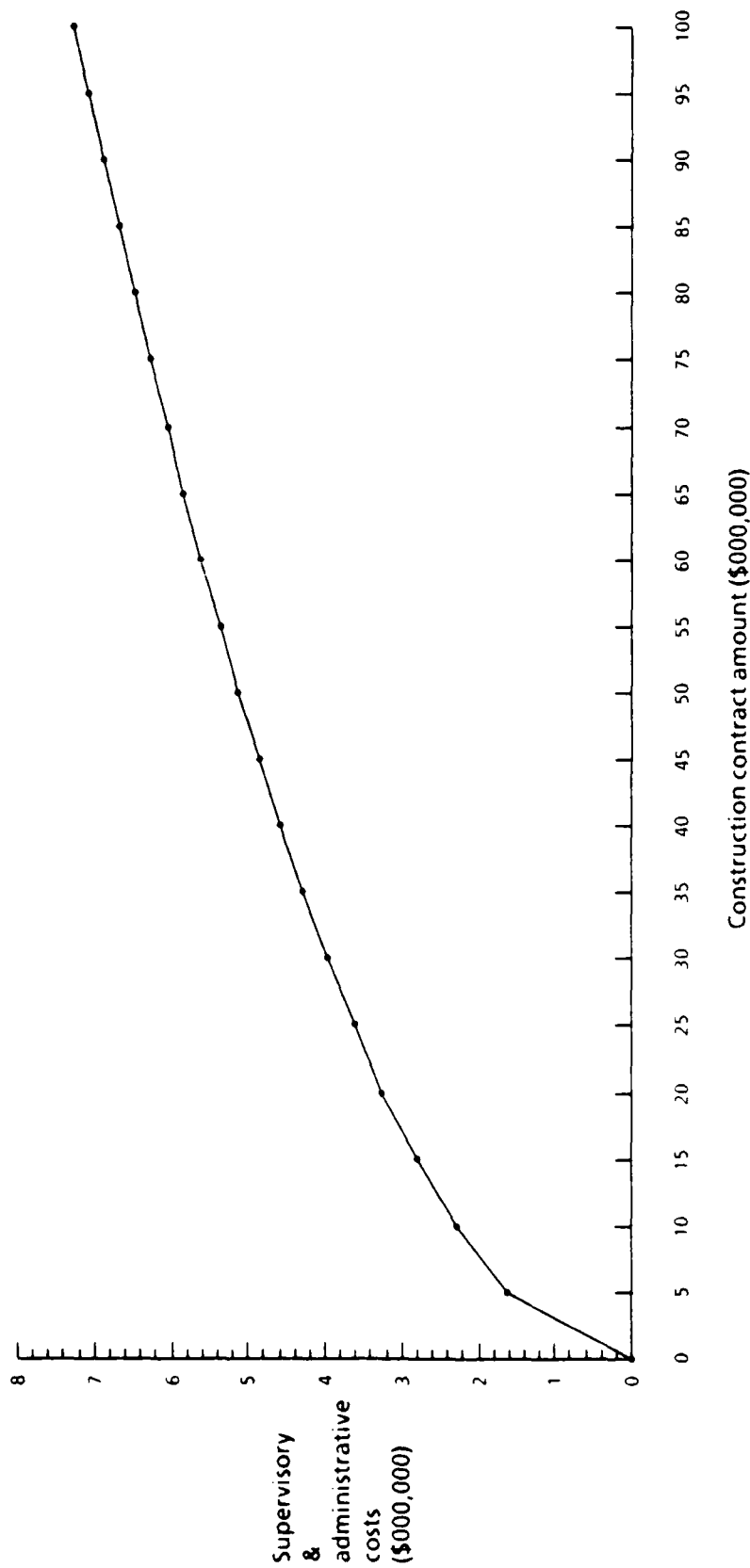
Notes: Supervisory & administrative costs = 725 * [Square root of construction contract amount]
(t = 21 5)   (Adjusted R-Square = 0 93)

FIG. C-16. SUPERVISORY & ADMINISTRATIVE COSTS FOR LOCKS/DAMS PROJECTS, O&M: LOCKS/DAMS PROJECTS, AND REHAB: LOCKS/DAMS PROJECTS

Supervisory & inspection costs ($000,000)

Construction contract amount ($000,000)
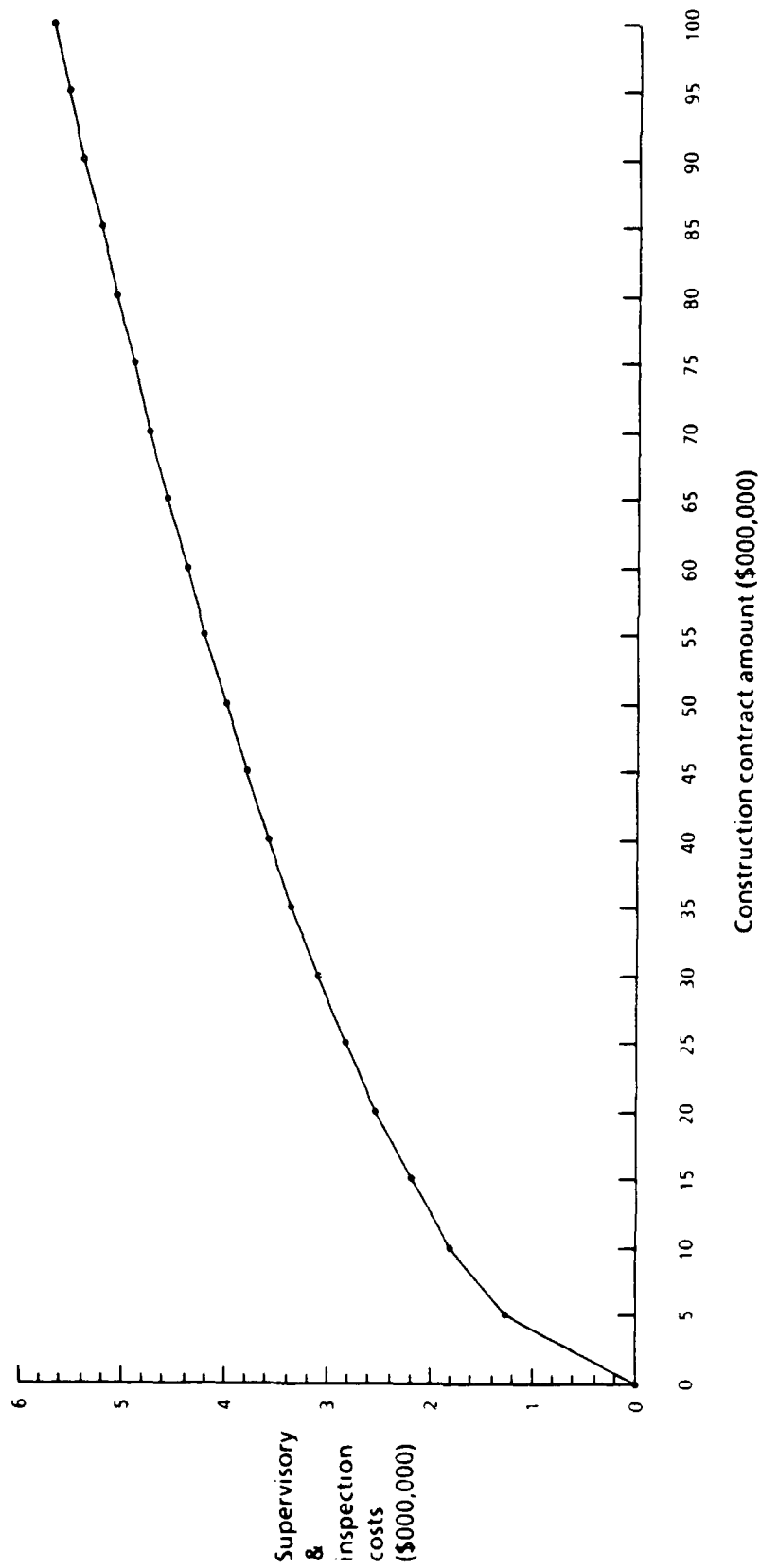
Notes: Supervisory & inspection costs = 567 * [Square root of construction contract amount]

(t = 14 7)   (Adjusted R-Square = 0 86)

FIG. C-17. SUPERVISORY & INSPECTION COSTS FOR LOCKS/DAMS PROJECTS, O&M: LOCKS/DAMS PROJECTS, AND REHAB: LOCKS/DAMS PROJECTS

Notes: General & administrative costs = 226 * [Square root of construction contract amount]
(t = 13 0)   (Adjusted R-Square = 0 83)

FIG. C-18. GENERAL & ADMINISTRATIVE COSTS FOR LOCKS/DAMS PROJECTS, O&M: LOCKS/DAMS PROJECTS, AND REHAB: LOCKS/DAMS PROJECTS
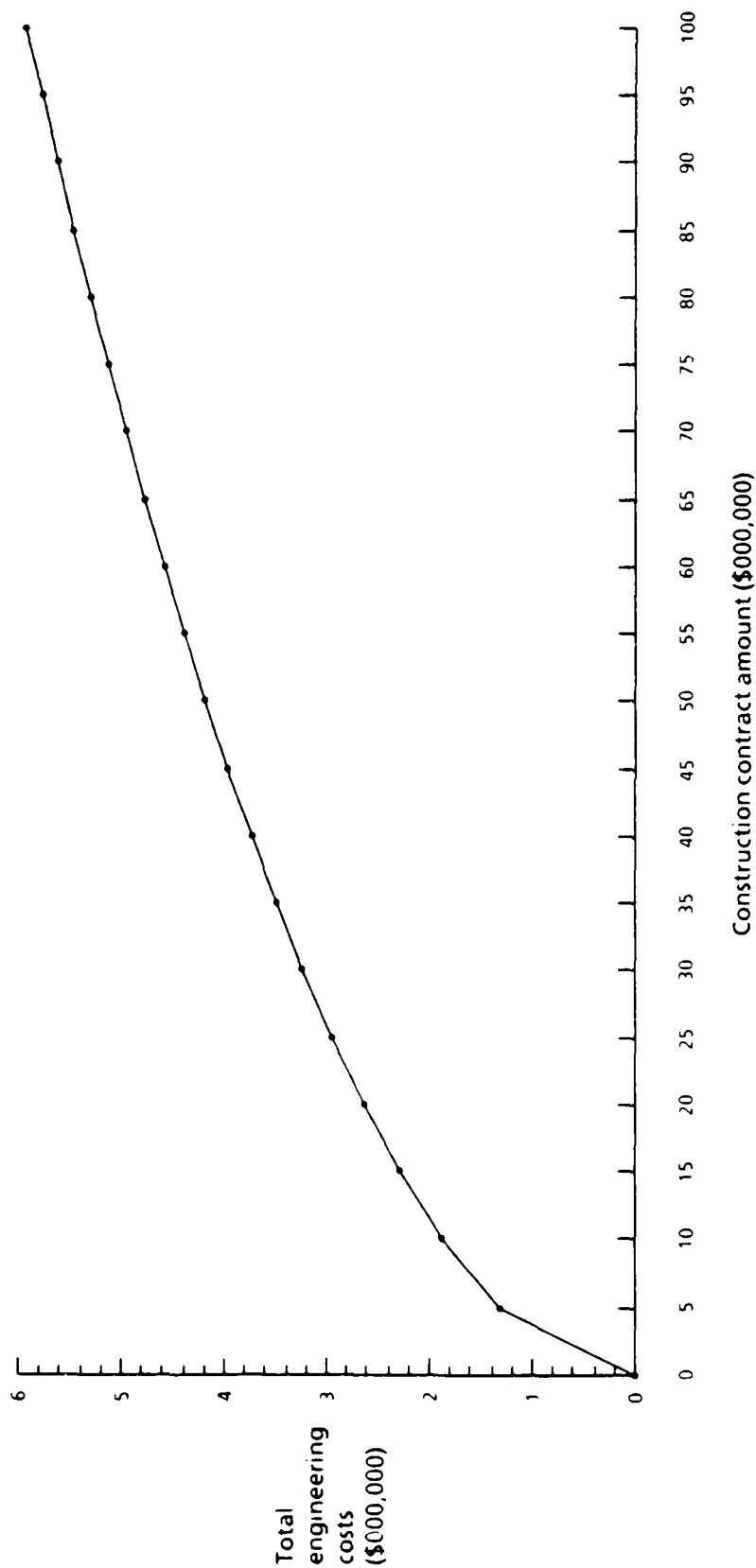
Notes: Total engineering costs = 592 * (Square root of construction contract amount)
(t = 19.8)   (Adjusted R-Square = 0.68)

FIG. C-19. TOTAL ENGINEERING COSTS FOR FLOOD CONTROL PROJECTS
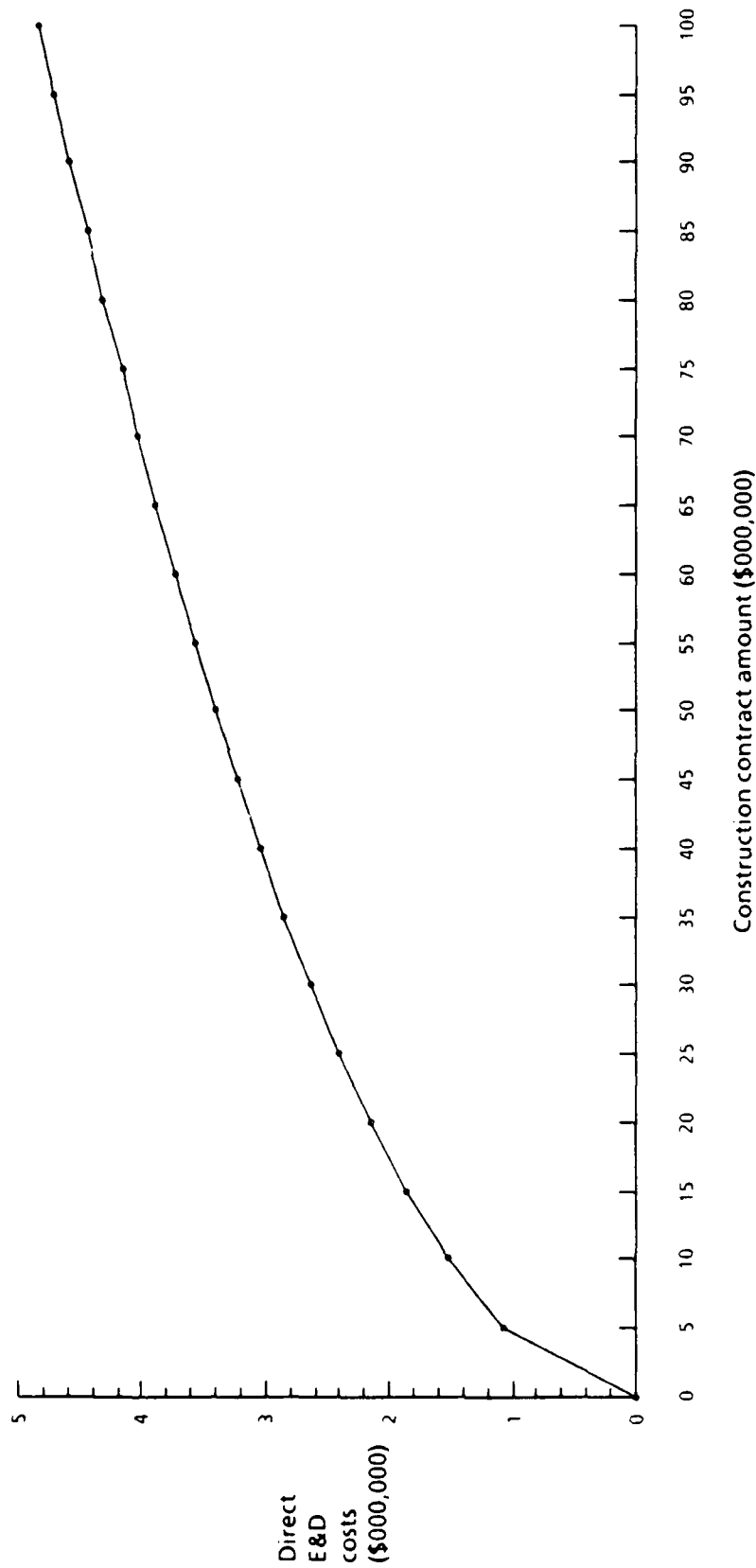
Notes: Direct E&D costs = 481 * [Square root of construction contract amount]
(t = 19 5)   (Adjusted R Square = 0 67)

FIG. C-20. DIRECT E&D COSTS FOR FLOOD CONTROL PROJECTS

Technical
Indirect
Costs
($000,000)

Construction contract amount ($000,000)
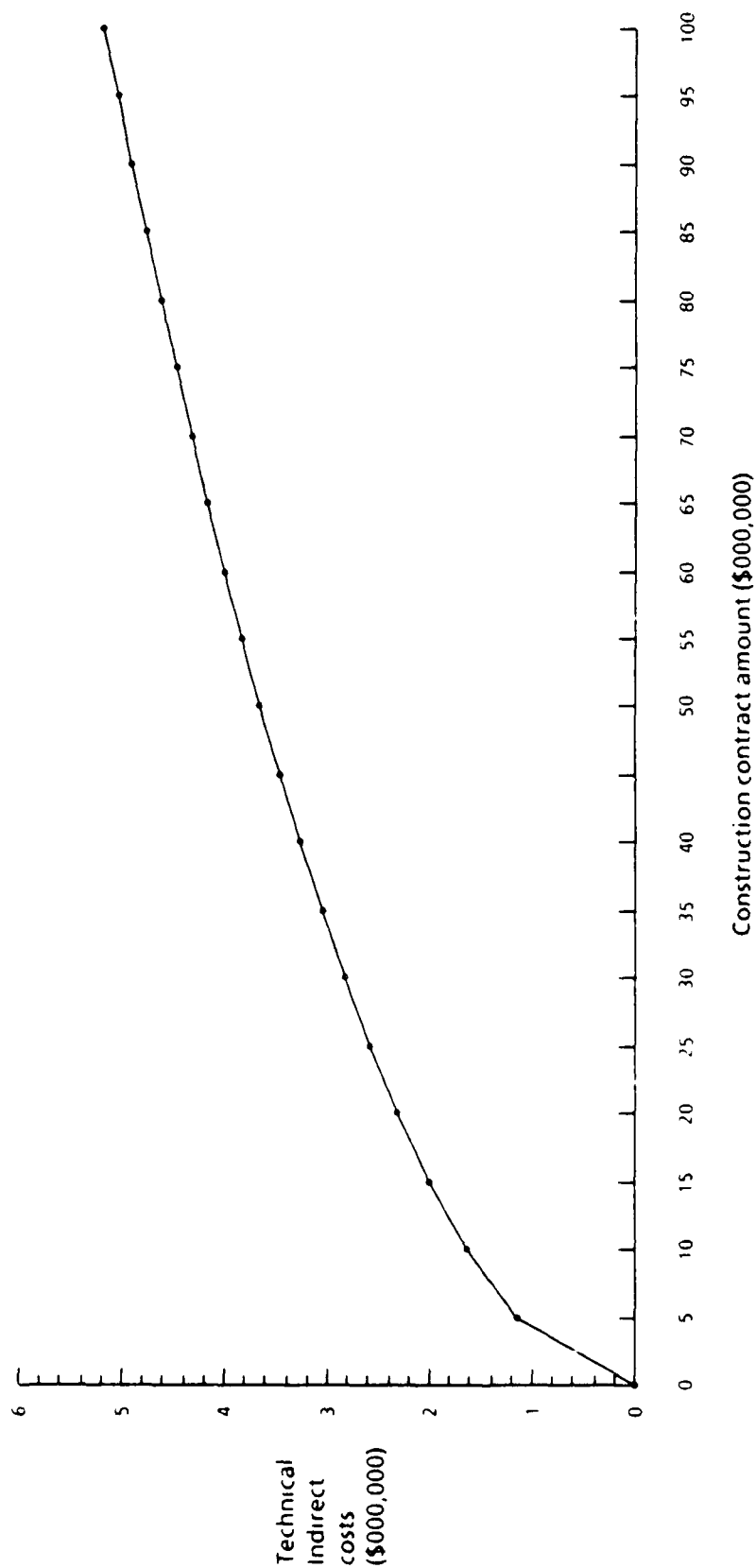
Notes: Technical indirect costs = 52 * [Square root of construction contract amount]
(t = 13 4) (Adjusted R Square – 0 49)
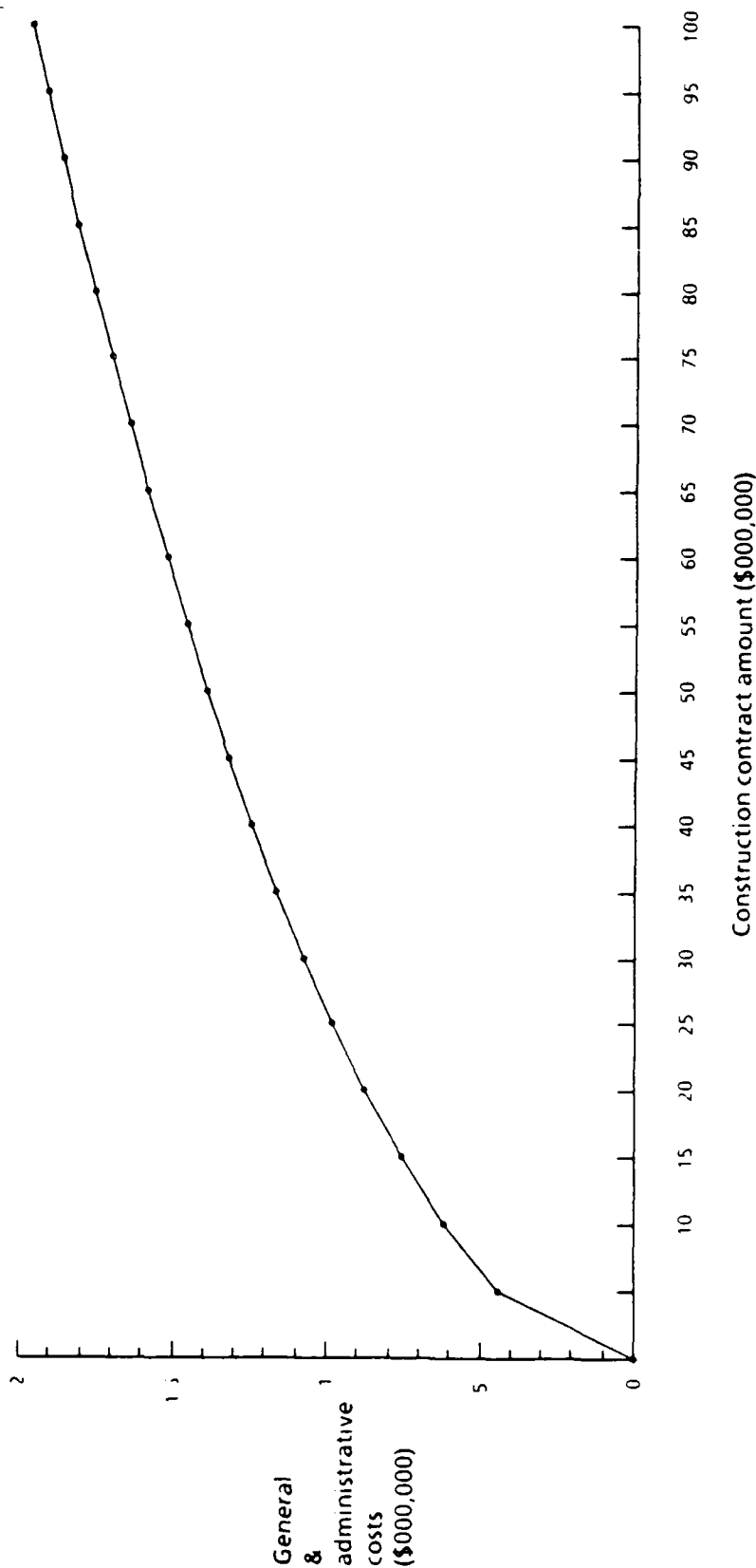
FIG. C-21. TECHNICAL INDIRECT COSTS FOR FLOOD CONTROL PROJECTS
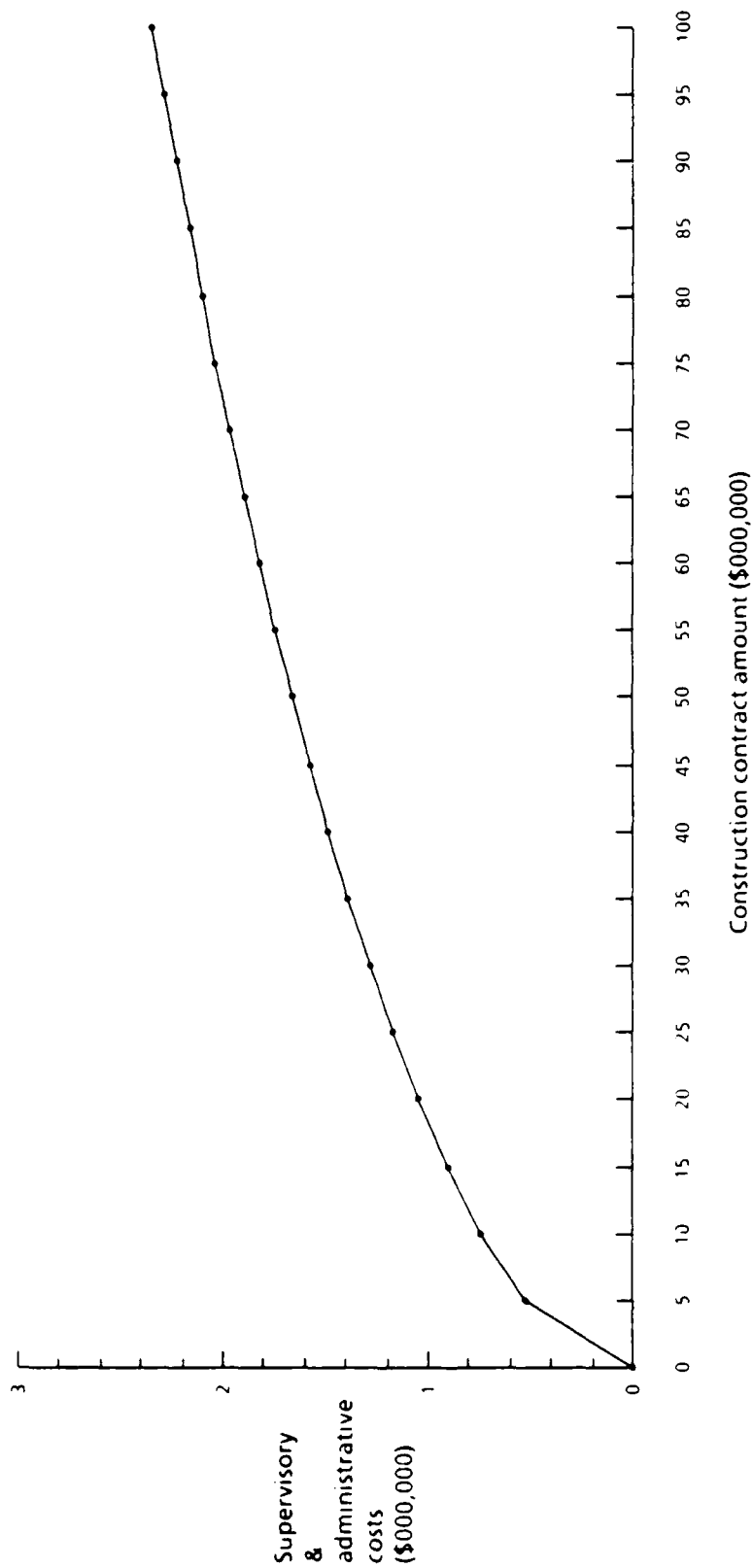
Notes: Supervisory & administrative costs = 235 * [Square root of construction contract amount]
(t = 24.9)   (Adjusted R Square = 0.77)

FIG. C-22. SUPERVISORY & ADMINISTRATIVE COSTS FOR FLOOD CONTROL PROJECTS

Supervisory & inspection costs ($000,000)

Construction contract amount ($000,000)
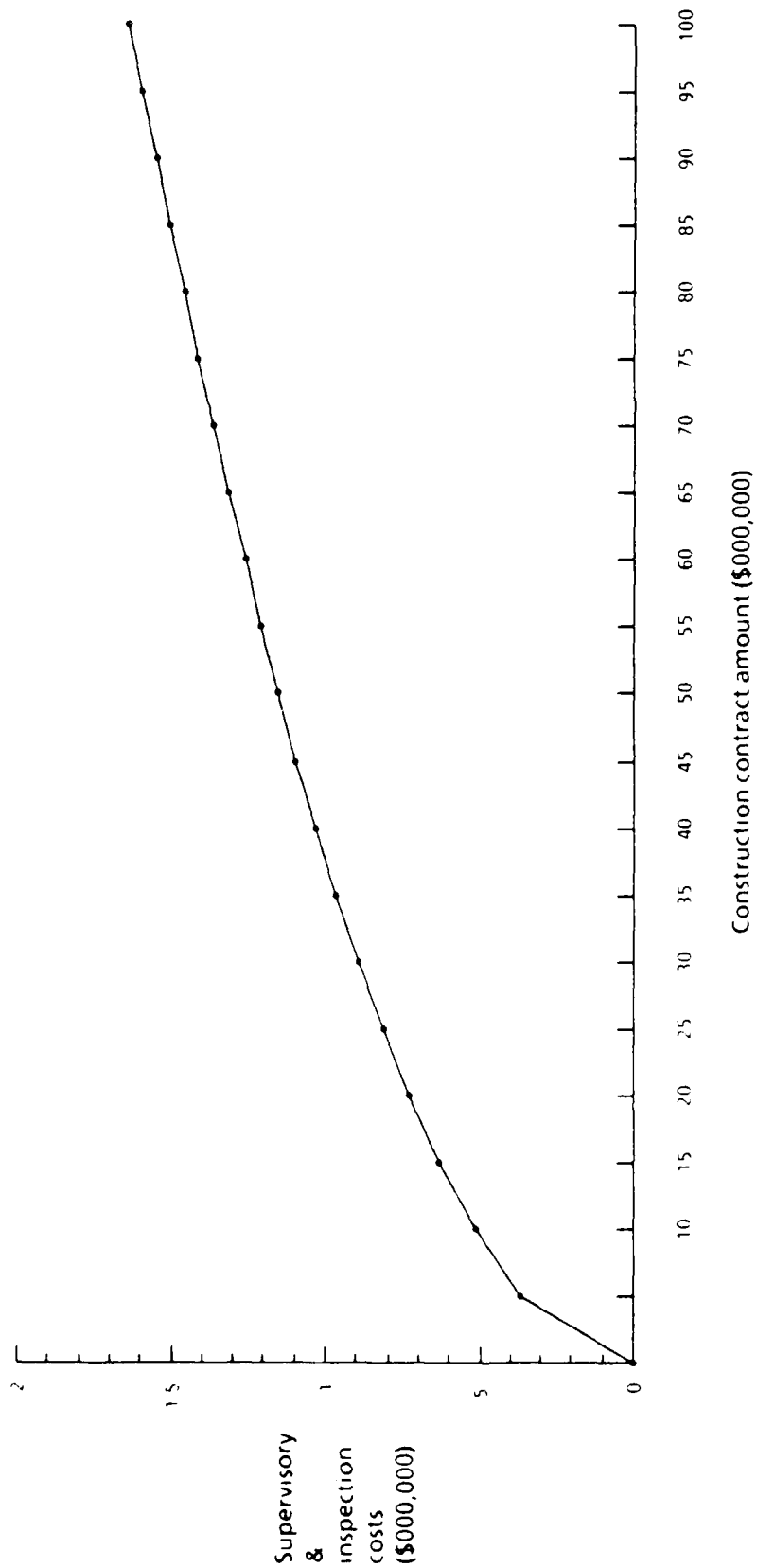
Notes: Supervisory & inspection costs = 163 * [Square root of construction contract amount]

(t = 27 8) (Adjusted R Square = 0 81)

FIG. C-23. SUPERVISORY & INSPECTION COSTS FOR FLOOD CONTROL PROJECTS
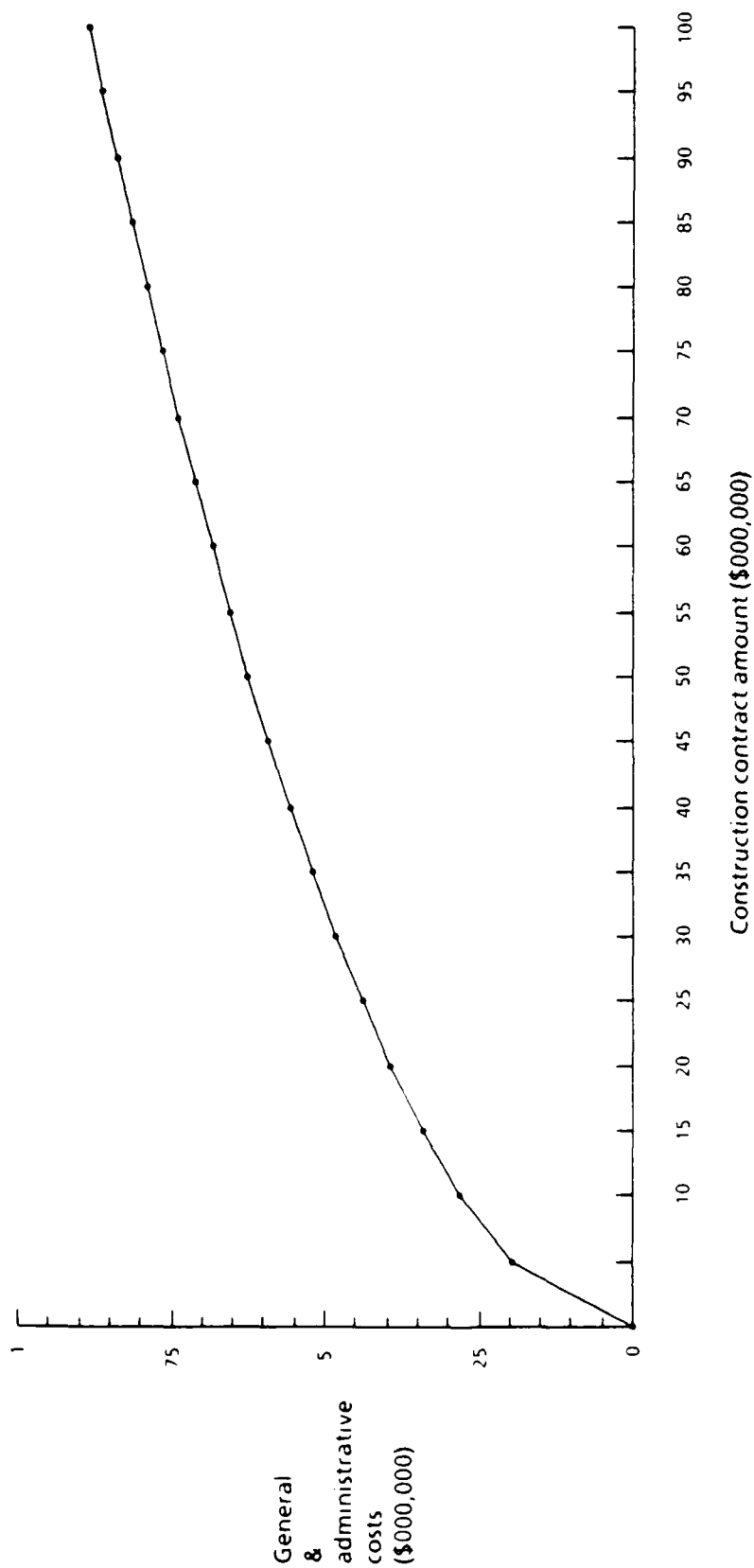
Notes: General & administrative costs = 88 * [Square root of construction contract amount]
(t = 18 0) (Adjusted R Square = 0 64)

FIG. C-24. GENERAL & ADMINISTRATIVE COSTS FOR FLOOD CONTROL PROJECTS
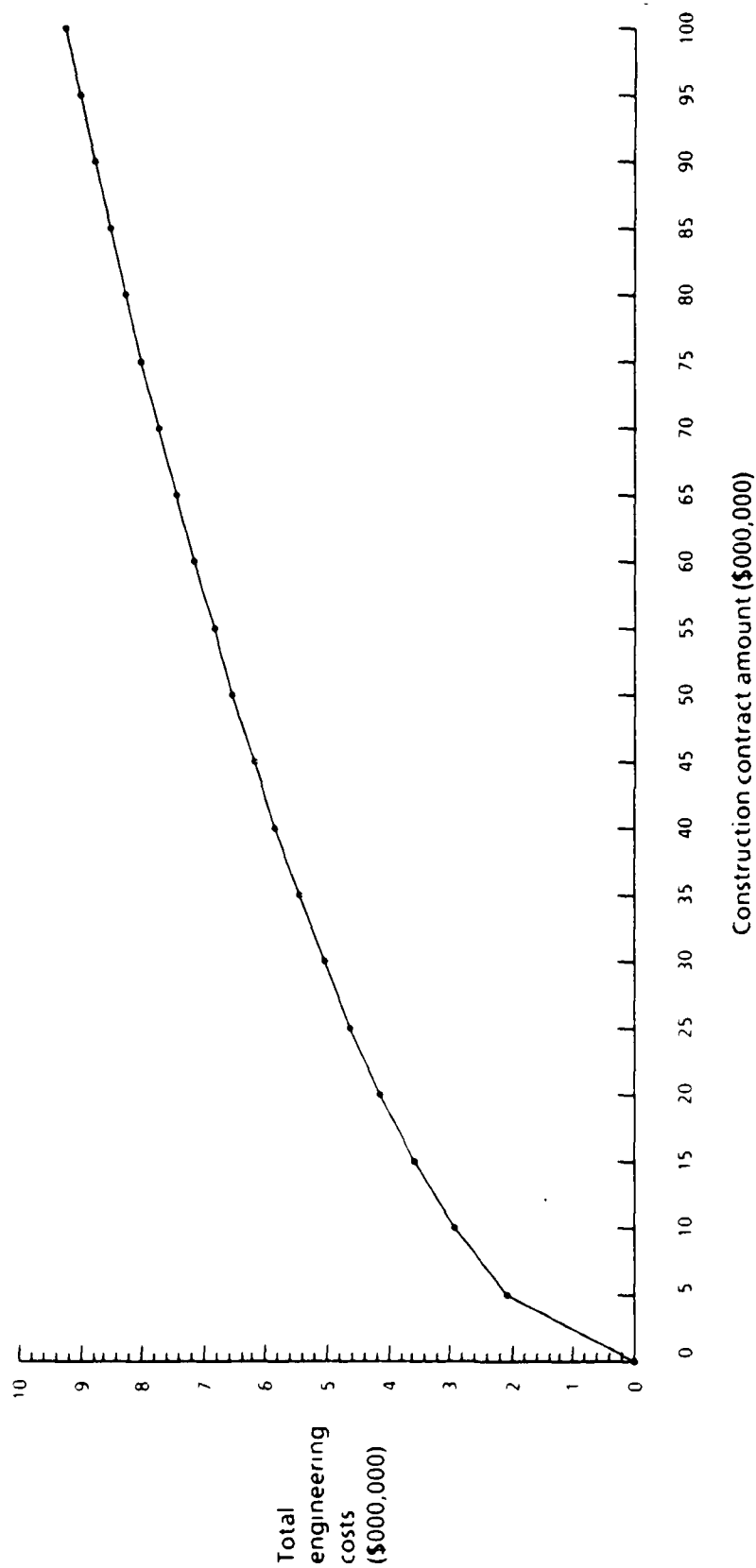
Notes: Total engineering costs = 923 * [Square root of construction contract amount]
(t = 13 8)   (Adjusted R Square = 0 81)

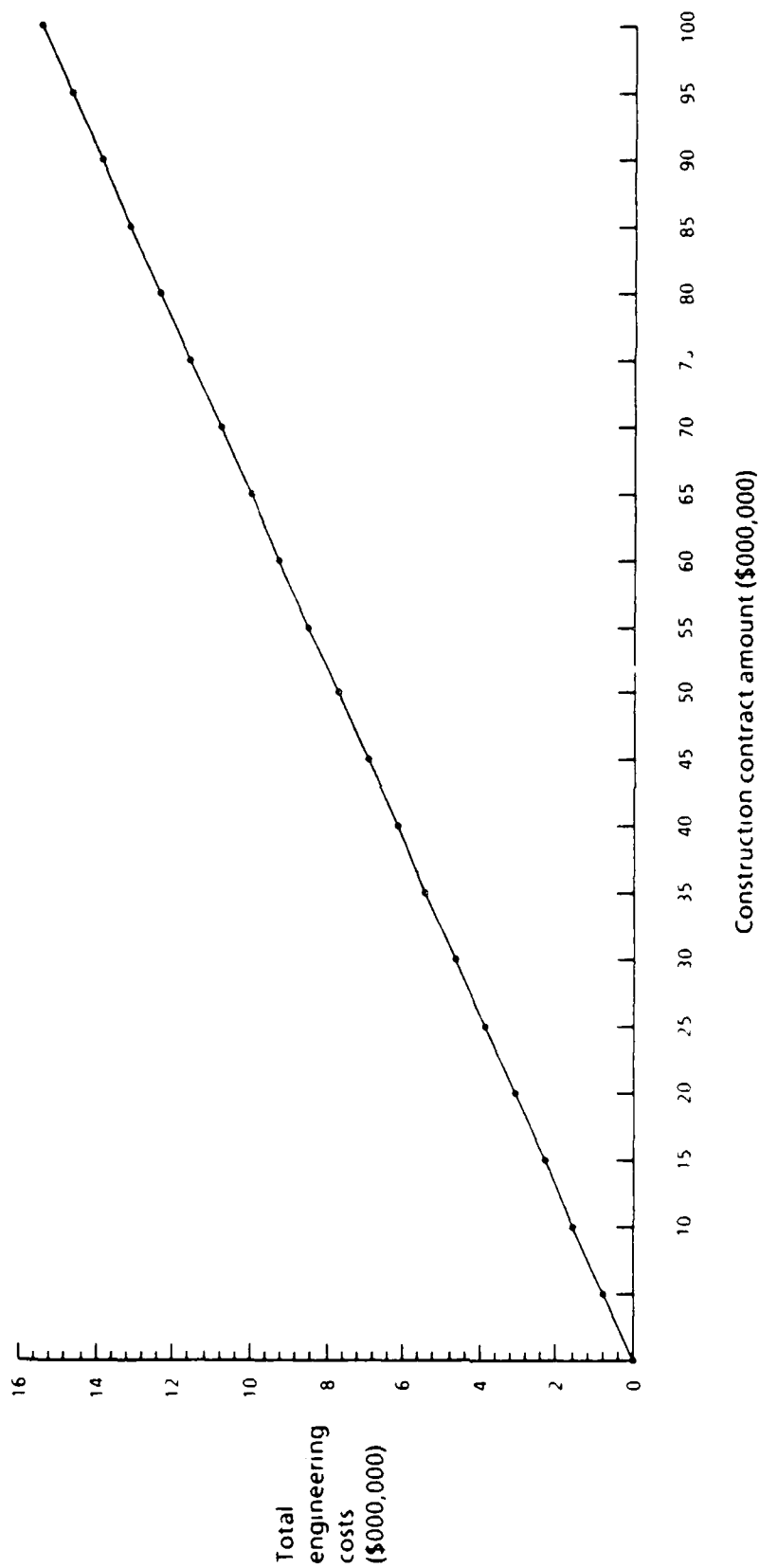**FIG. C-25. TOTAL ENGINEERING COSTS FOR FLOOD CONTROL RESERVOIR PROJECTS AND O&M: FLOOD CONTROL RESERVOIR PROJECTS**
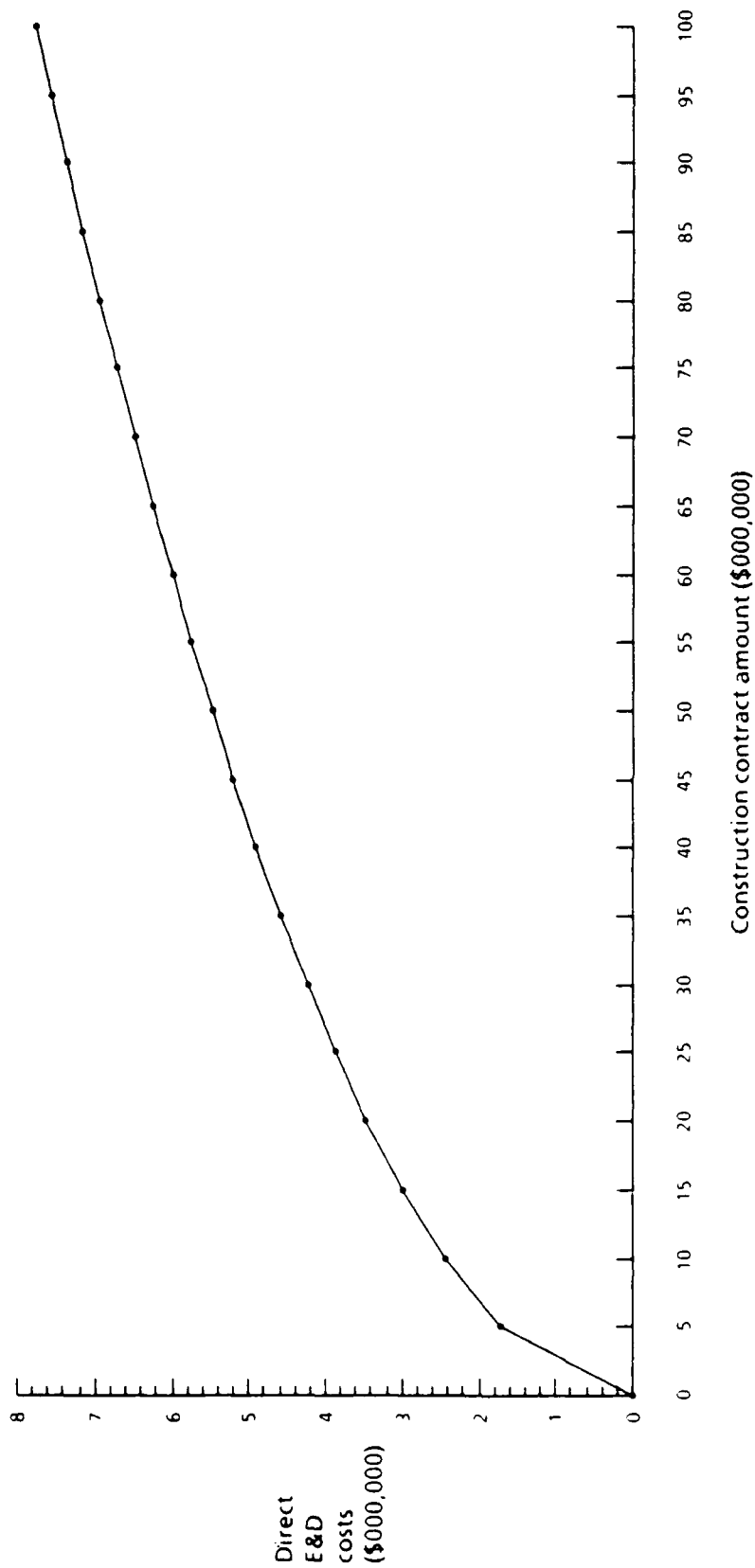
Notes: Direct E&D costs = 7/5 * [Square root of construction contract amount]
(t = 14 3) (Adjusted R Square = 0 82)

FIG. C-26. DIRECT E&D COSTS FOR FLOOD CONTROL RESERVOIR PROJECTS AND O&M: FLOOD CONTROL RESERVOIR PROJECTS

Technical
Indirect
costs
($000,000)

Construction contract amount ($000,000)
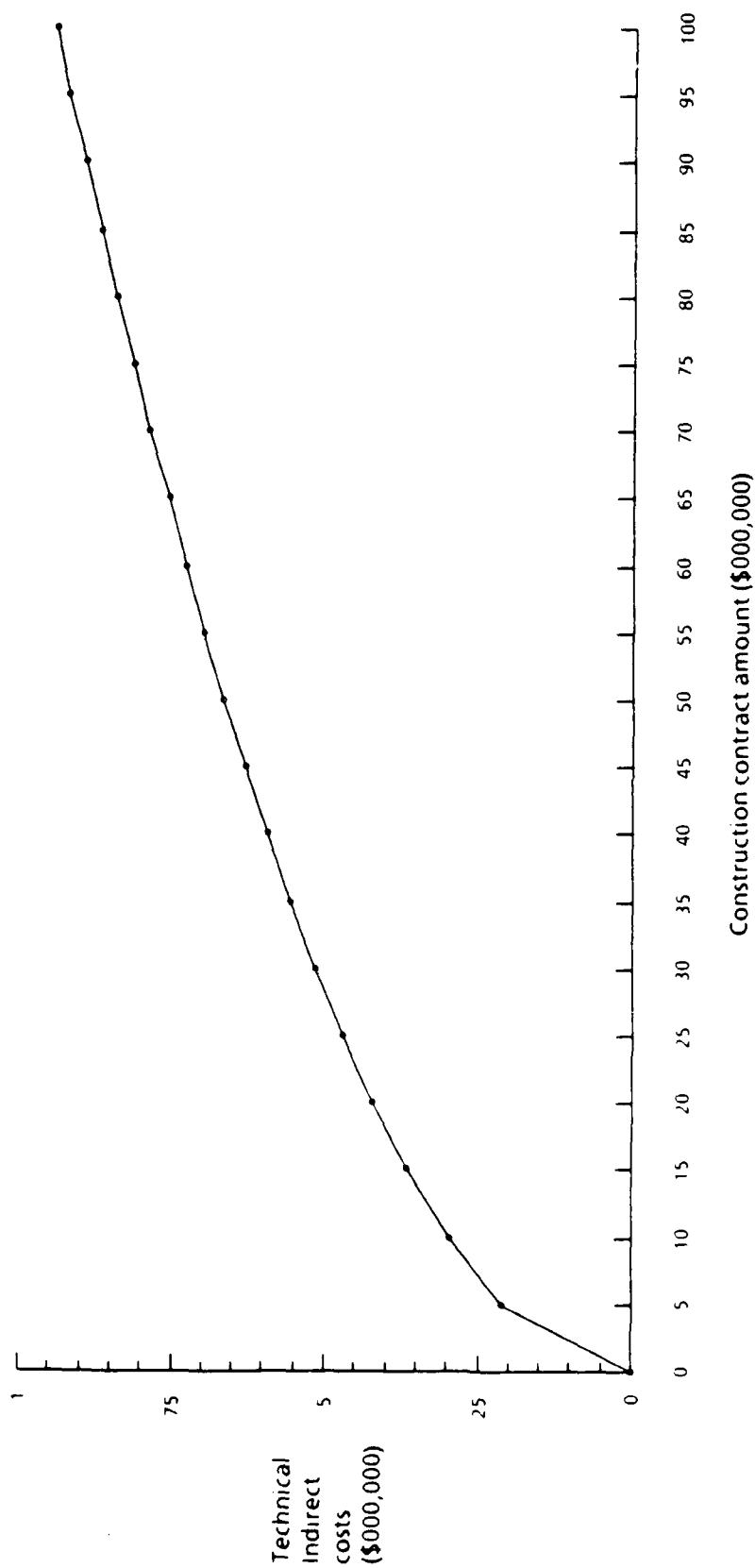
Notes: Technical indirect costs = 94 * |Square root of construction contract amount|
(t = 6 4)   (Adjusted R-Square = 0 47)

FIG. C-27. TECHNICAL INDIRECT COSTS FOR FLOOD CONTROL RESERVOIR PROJECTS AND O&M: FLOOD CONTROL RESERVOIR PROJECTS

C-30

Supervisory
&
administrative
costs
($000,000)

Construction contract amount ($000,000)
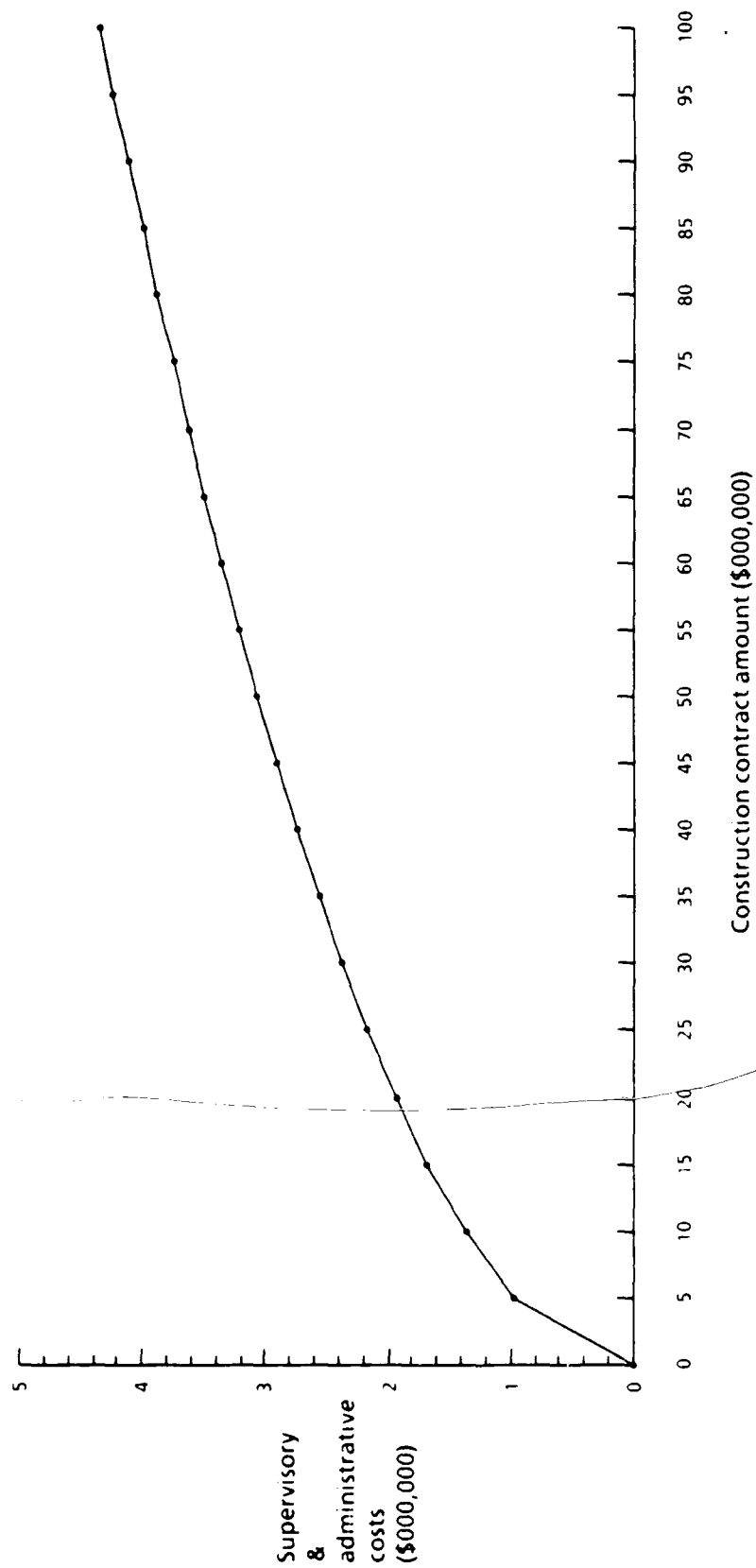
Notes: Supervisory & administrative costs = 433 * [Square root of construction contract amount]

(t = 21.8)   (Adjusted R-Square = 0.91)

FIG. C-28. SUPERVISORY & ADMINISTRATIVE COSTS FOR FLOOD CONTROL RESERVOIR PROJECTS AND O&M: FLOOD CONTROL RESERVOIR PROJECTS
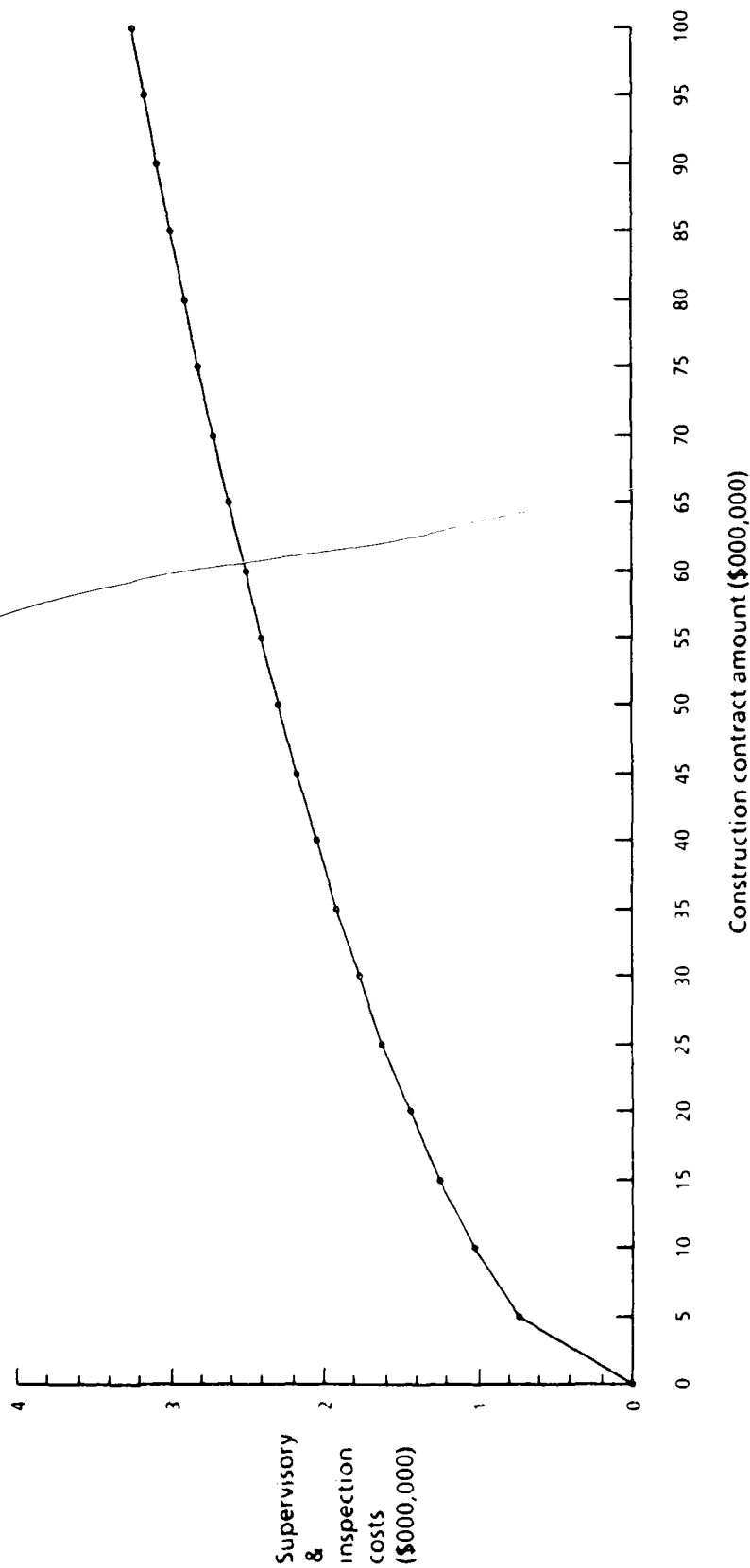
Notes: Supervisory & inspection costs = 3.24 * (Square root of construction contract amount)
(t = 19.2)   (Adjusted R Square = 0.89)

**FIG. C-29. SUPERVISORY & INSPECTION COSTS FOR FLOOD CONTROL RESERVOIR PROJECTS
AND O&M: FLOOD CONTROL RESERVOIR PROJECTS**

Notes: General & administrative costs = 196 * [Square root of construction contract amount]
(t = 14 8)   (Adjusted R-Square = 0 83)

FIG. C-30. GENERAL & ADMINISTRATIVE COSTS FOR FLOOD CONTROL RESERVOIR PROJECTS AND O&M: FLOOD CONTROL RESERVOIR PROJECTS

Notes: Total engineering costs = 0 154 * (Construction contract amount)
(t = 12 5)   (Adjusted R Square = 0 82)

FIG. C-31. TOTAL ENGINEERING COSTS FOR O&M: FLOOD CONTROL PROJECTS. FLOOD CONTROL PROJECTS. FLOOD CONTROL: REHABILITATION PROJECTS. AND FLOOD CONTROL: CONSTRUCTION PROJECTS
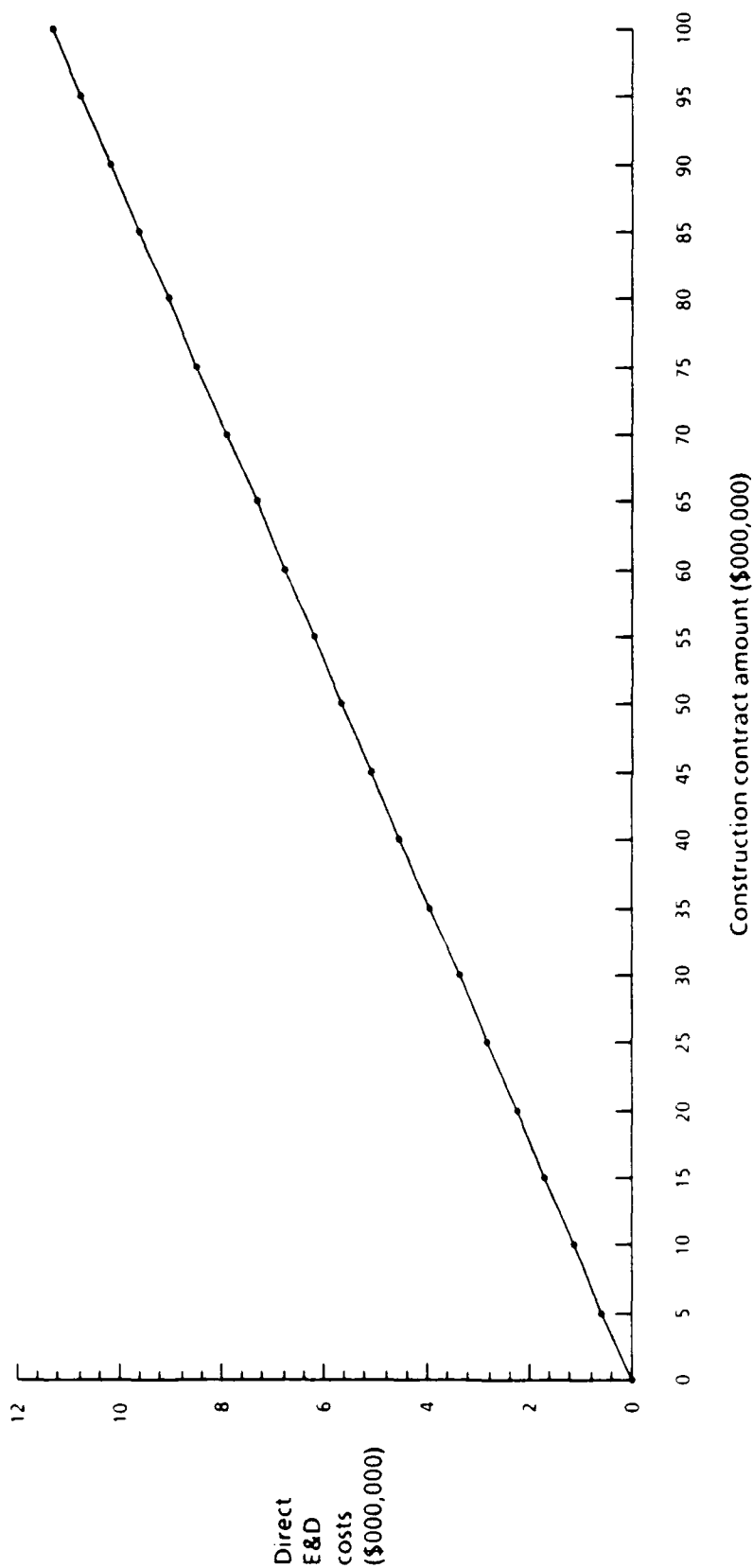
Notes: Direct E&D costs = 0.113 * [Construction contract amount]
(t = 13.0)   (Adjusted R Square = 0.83)

FIG. C-32. DIRECT E&D COSTS FOR O&M: FLOOD CONTROL PROJECTS, FLOOD CONTROL: REHABILITATION PROJECTS, AND FLOOD CONTROL: CONSTRUCTION PROJECTS
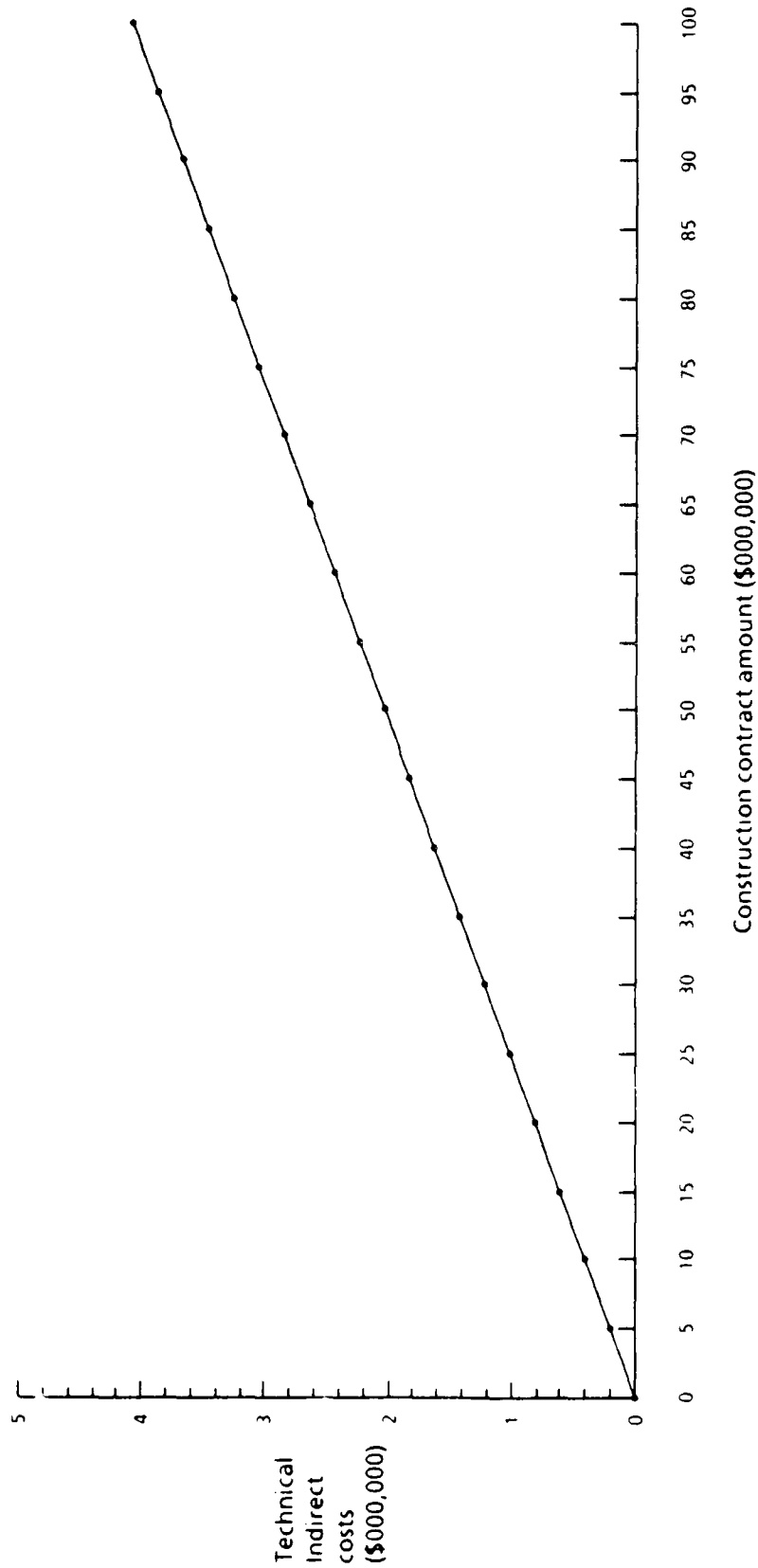
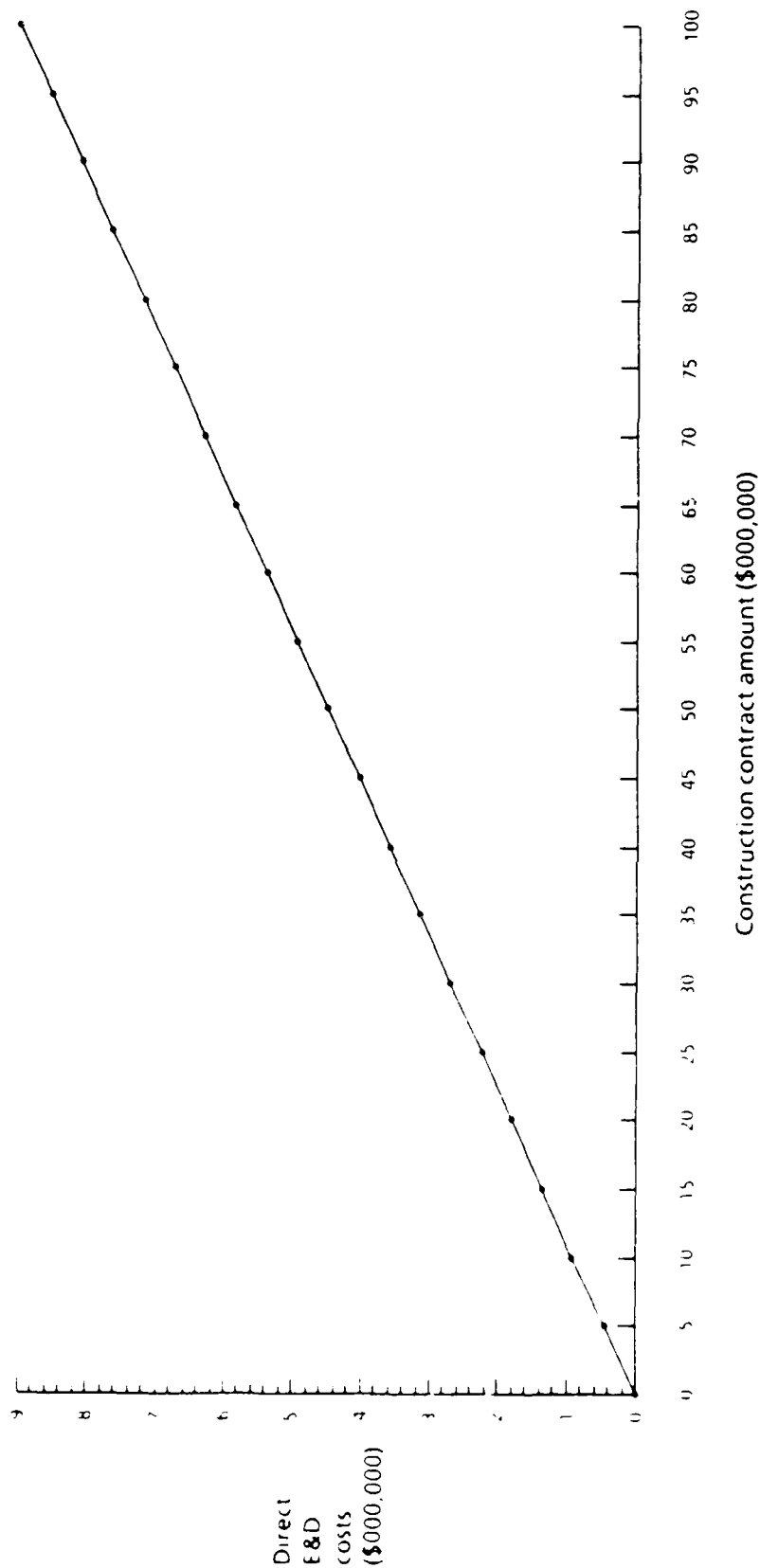Notes: Technical indirect costs = 0 041 * (Construction contract amount)
(t = 11 2)   (Adjusted R-Square = 0 79)

FIG. C-33. TECHNICAL INDIRECT COSTS FOR O&M: FLOOD CONTROL PROJECTS, FLOOD CONTROL: REHABILITATION PROJECTS,
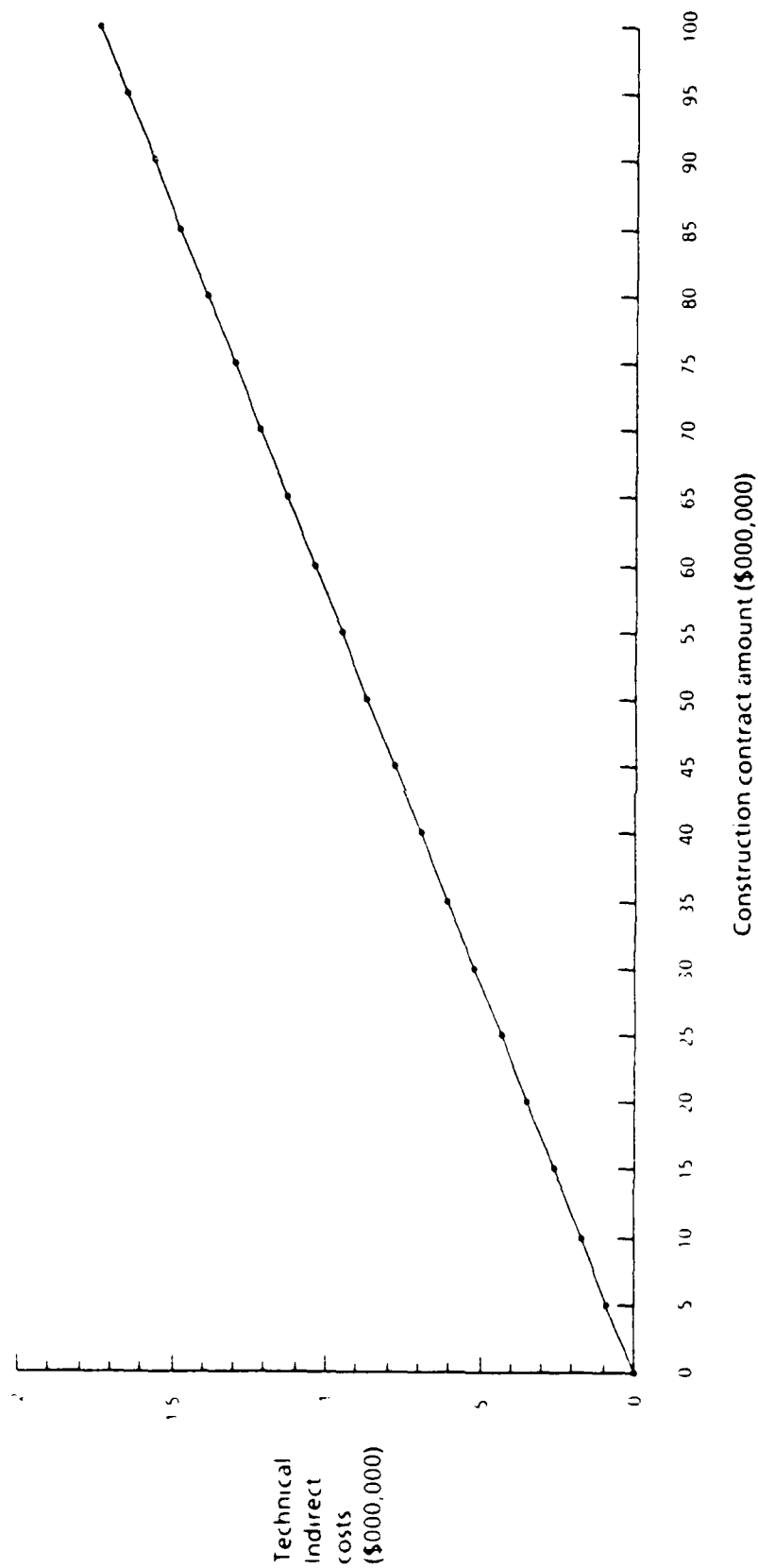AND FLOOD CONTROL: CONSTRUCTION PROJECTS

Supervisory
&
administrative
costs
($000,000)

Construction contract amount ($000,000)
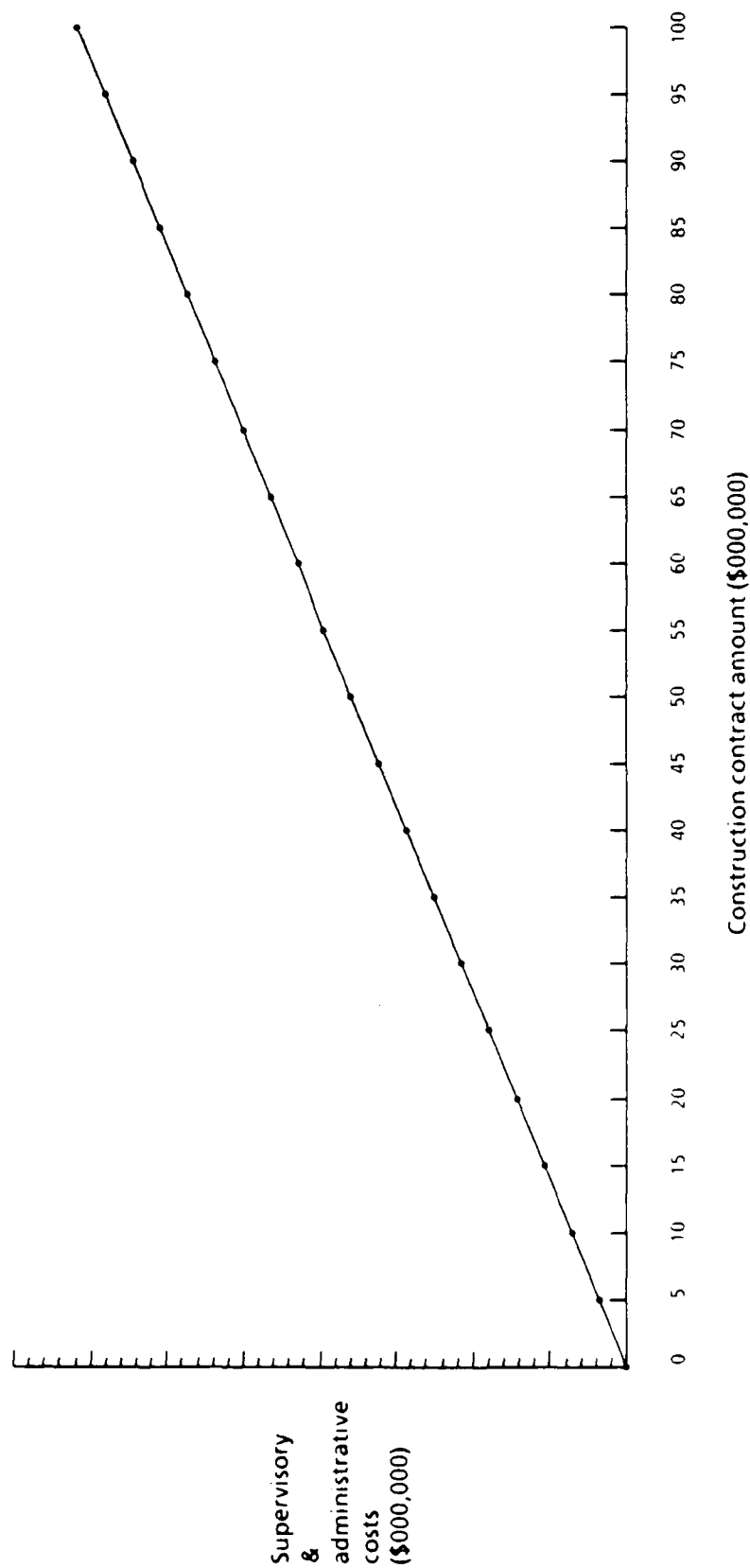
Notes: Supervisory & administrative costs = 0 072 * [Construction contract amount]
(t = 34 6)   (Adjusted R-Square = 0 97)

**FIG. C-34. SUPERVISORY & ADMINISTRATIVE COSTS FOR O&M: FLOOD CONTROL PROJECTS, FLOOD CONTROL: REHABILITATION
PROJECTS, AND FLOOD CONTROL: CONSTRUCTION PROJECTS**

Construction contract amount ($000,000)

Supervisory & inspection costs ($000,000)
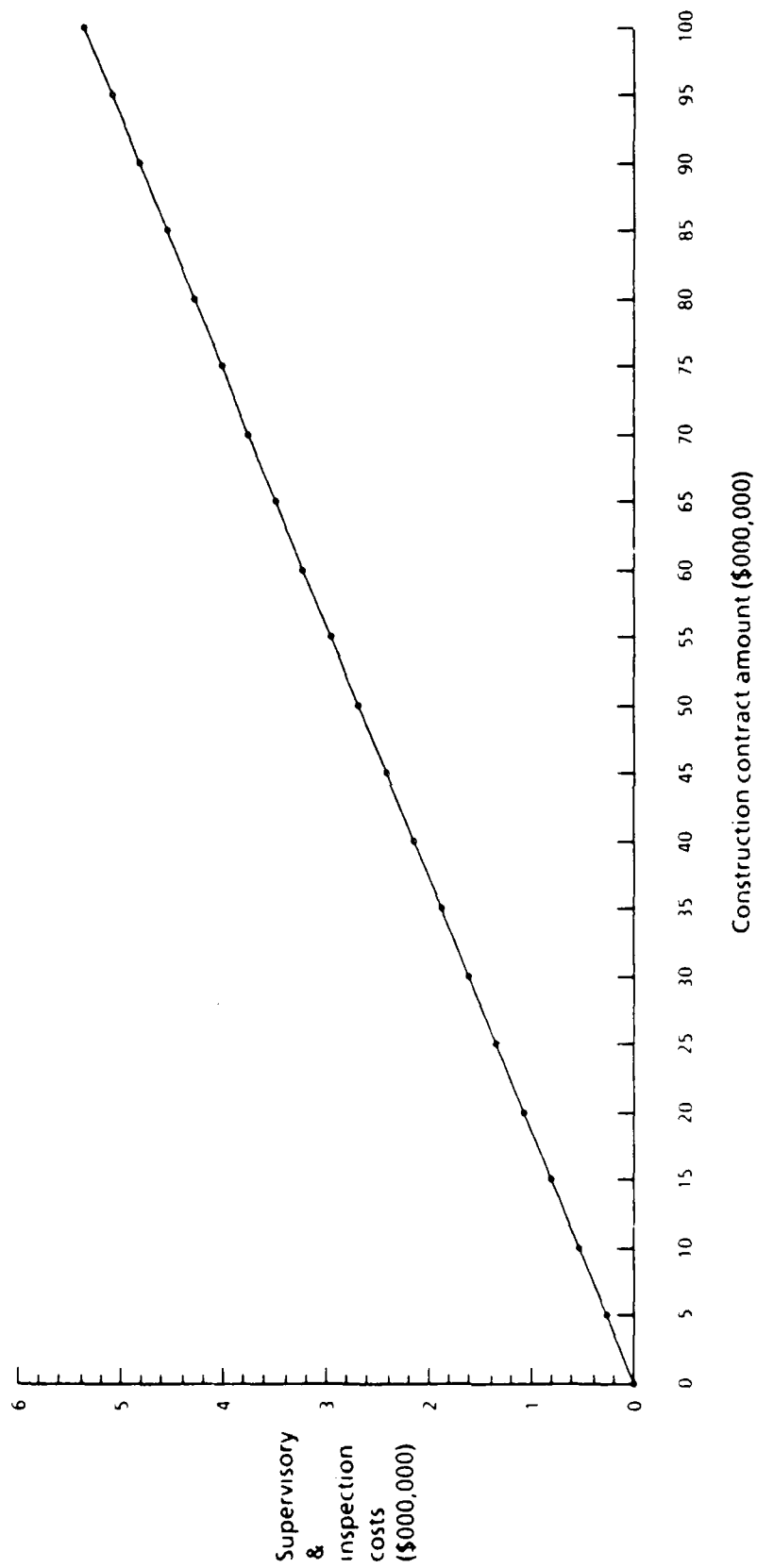
Notes: Supervisory & inspection costs = 0.053 * [Construction contract amount]
($t = 75.1$) (Adjusted R Square = 0.99)

FIG. C-35. SUPERVISORY & INSPECTION COSTS FOR O&M: FLOOD CONTROL PROJECTS, FLOOD CONTROL: REHABILITATION PROJECTS, AND FLOOD CONTROL: CONSTRUCTION PROJECTS

Construction contract amount ($000,000)

General & administrative costs ($000,000)
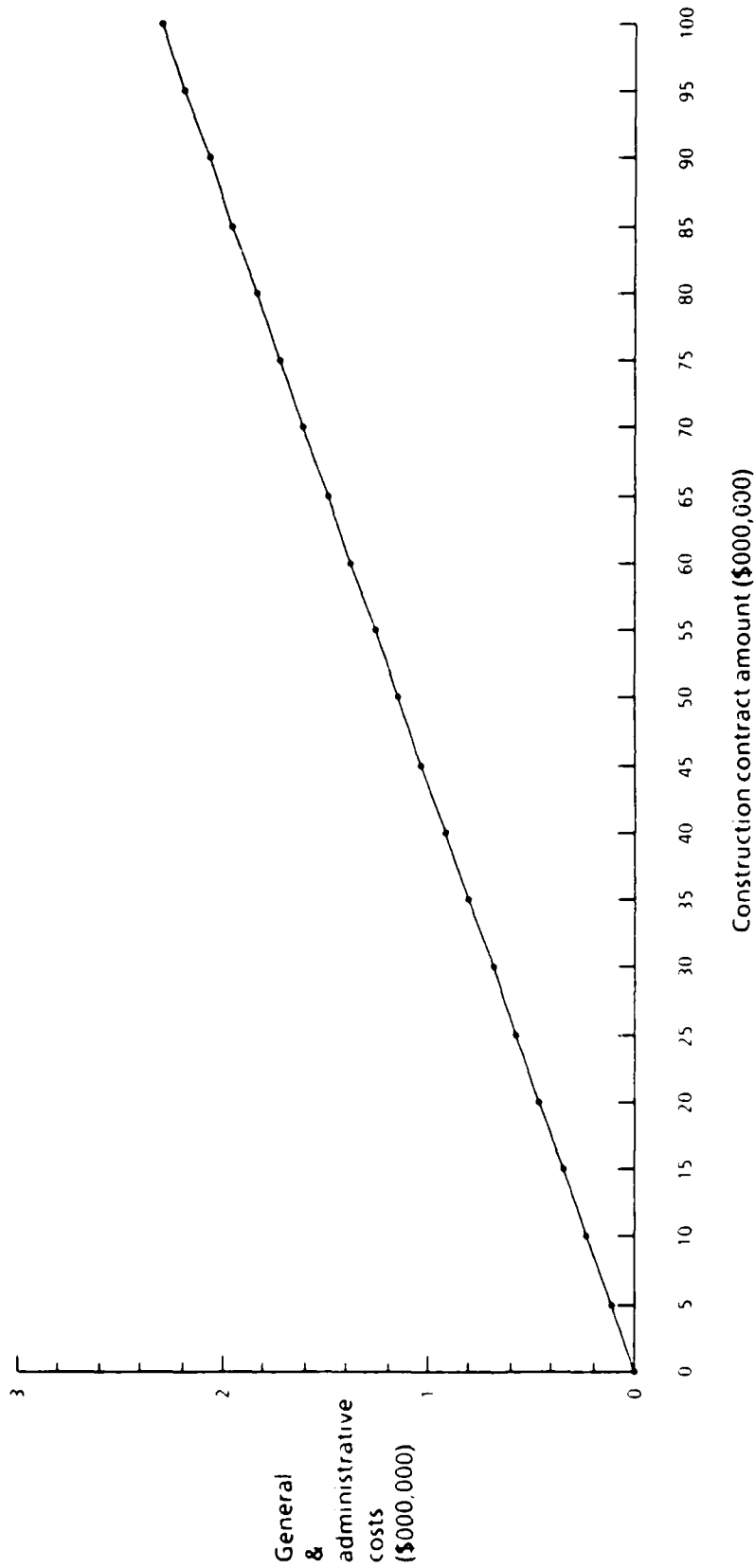
Notes: General & administrative costs = 0.023 * (Construction contract amount)
(t = 10.5)   (Adjusted R-Square = 0.76)

FIG. C-36. GENERAL & ADMINISTRATIVE COSTS FOR O&M: FLOOD CONTROL PROJECTS, FLOOD CONTROL: REHABILITATION PROJECTS, AND FLOOD CONTROL: CONSTRUCTION PROJECTS

Construction contract amount ($000,000)

Total engineering costs ($000,000)
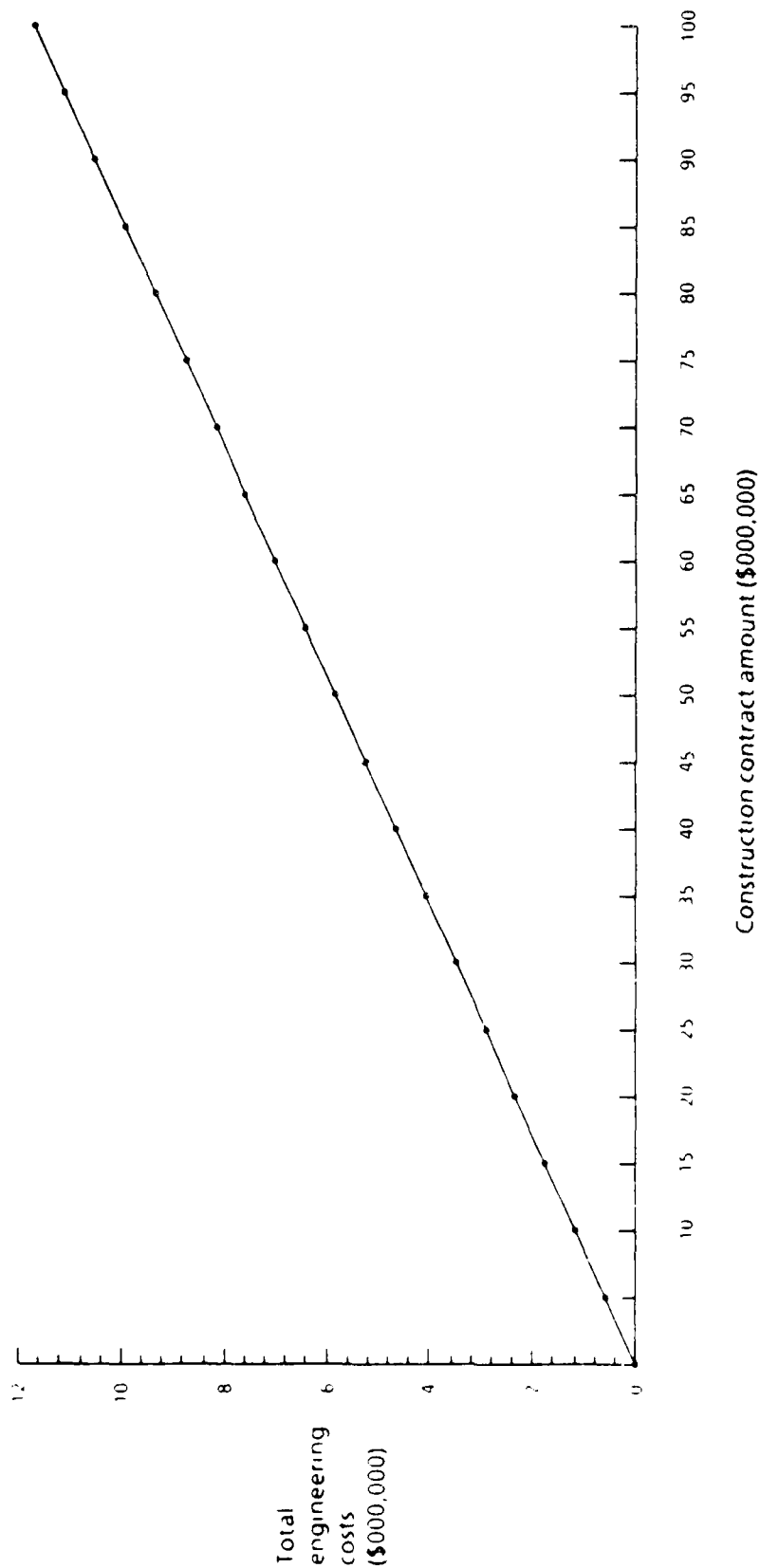
Notes Total engineering costs = 0 117 * [Construction contract amount]
(t = 19 9)   (Adjusted R Square = 0 91)

FIG. C-37 TOTAL ENGINEERING COSTS FOR MULTIPURPOSE POWER PROJECTS AND O&M: MULTIPURPOSE POWER PROJECTS
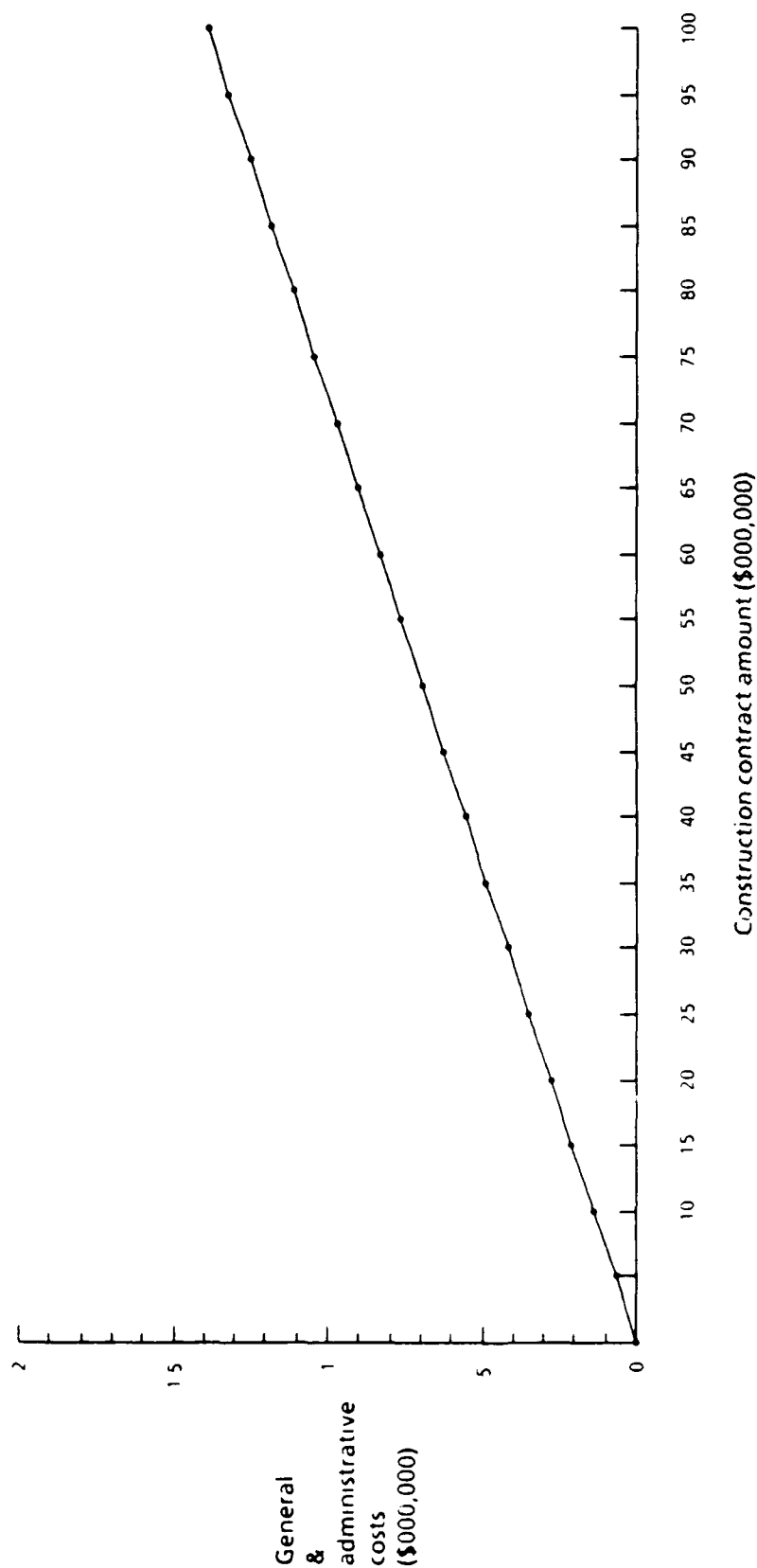
Notes Direct E&D costs = 0.090 * [Construction contract amount]
(1 - 30.9)   (Adjusted R Square = 0.96)

FIG. C-38. DIRECT E&D COSTS FOR MULTIPURPOSE POWER PROJECTS AND O&M: MULTIPURPOSE POWER PROJECTS

Technical
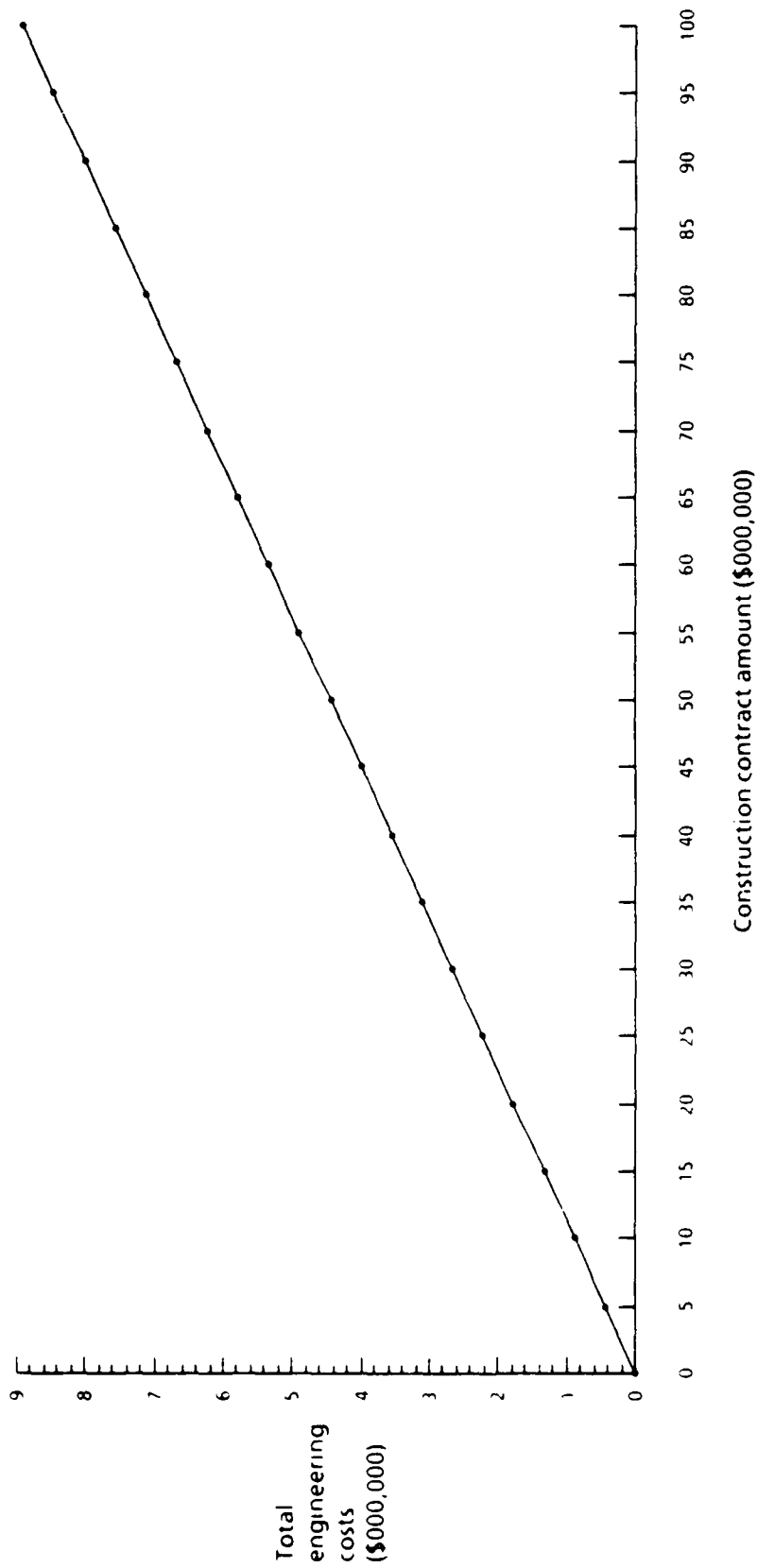Indirect
costs
($000,000)

Construction contract amount ($000,000)

Notes Technical indirect costs = 0.017 * [(construction contract amount]

(t - 9.0)   (Adjusted R Square = 0.66)

FIG C-39. TECHNICAL INDIRECT COSTS FOR MULTIPURPOSE POWER PROJECTS AND O&M: MULTIPURPOSE POWER PROJECTS
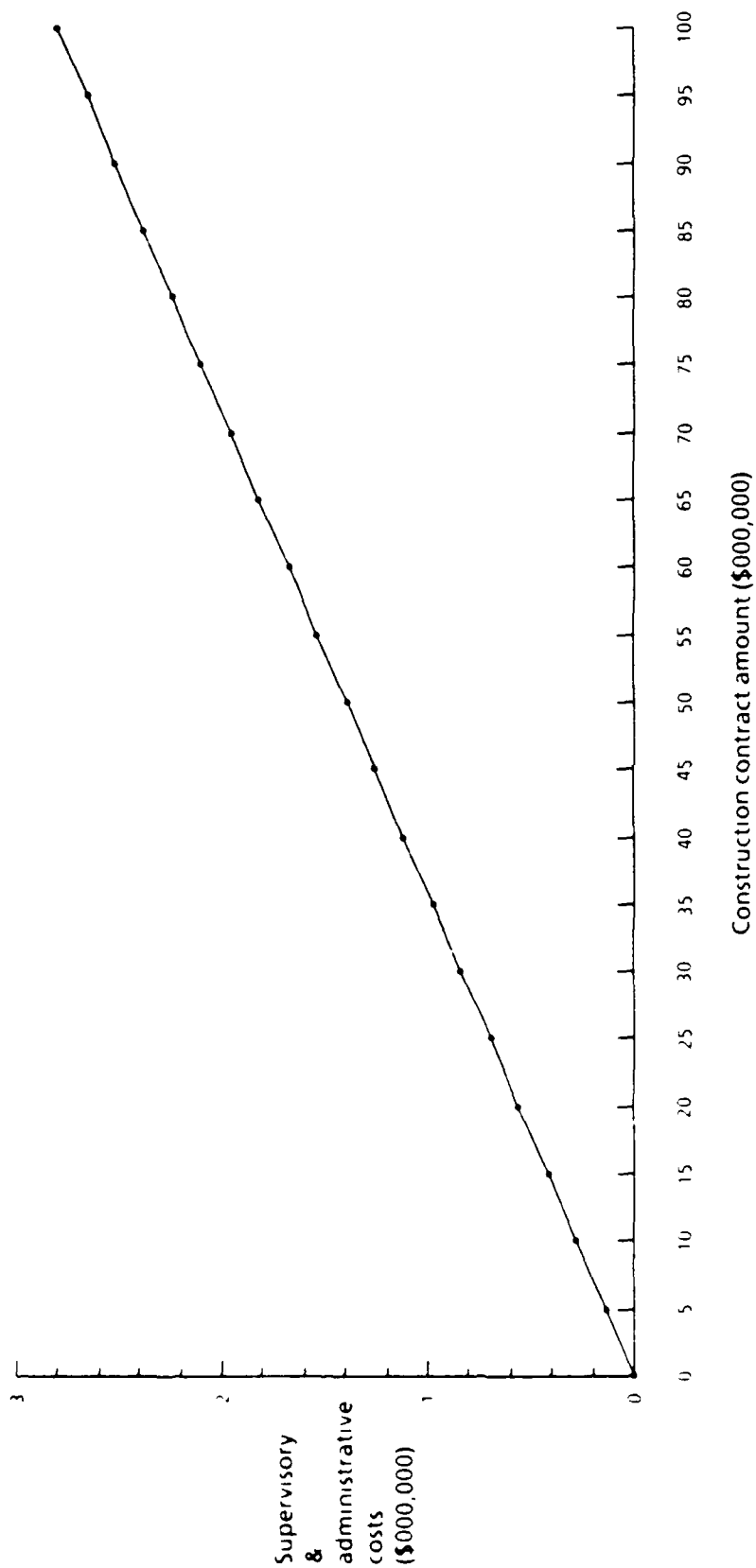
Notes Supervisory & administrative costs = 0 028 * (Construction contract amount)
(t – 22 0) (Adjusted R Square = 0 92)

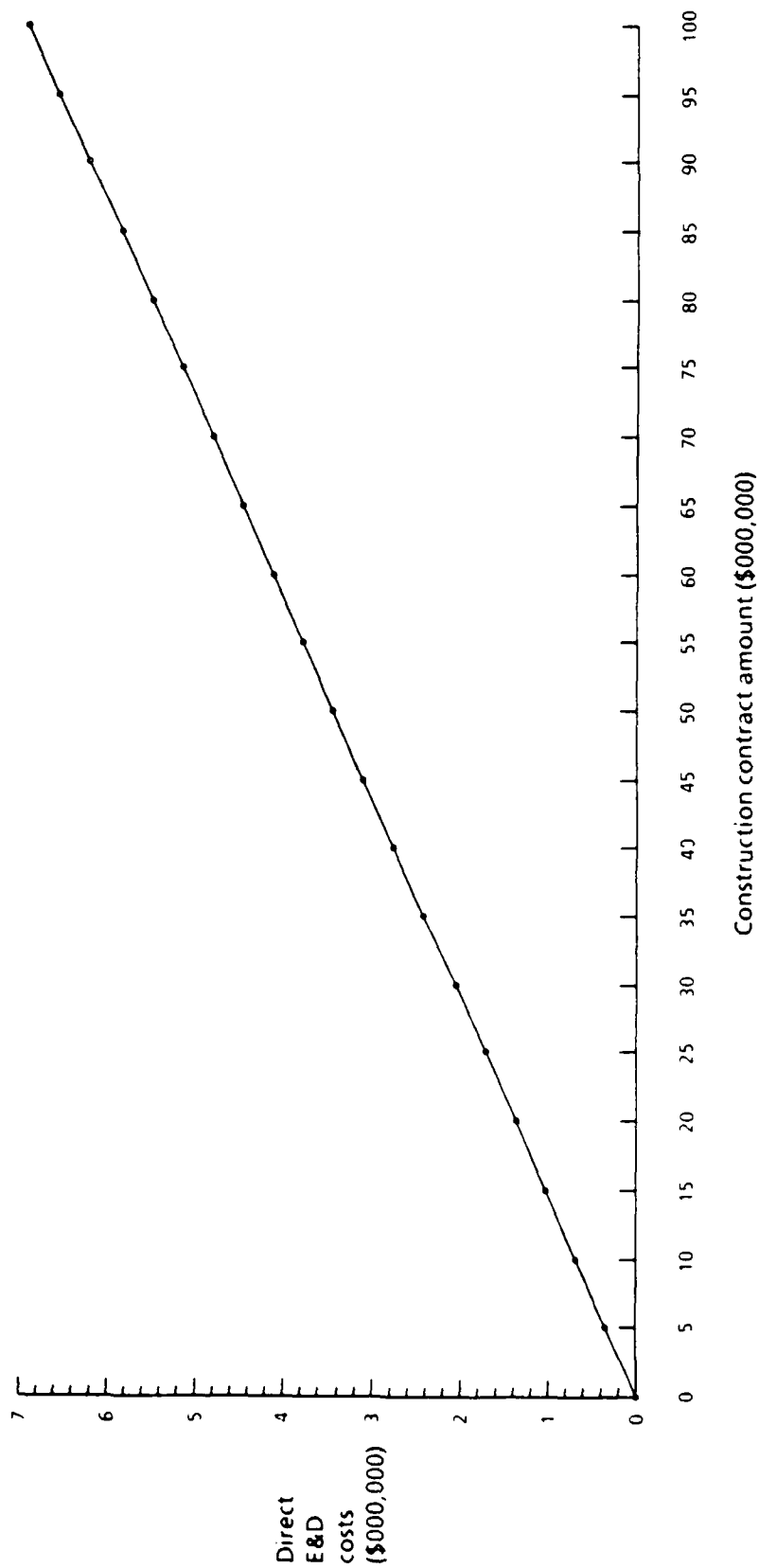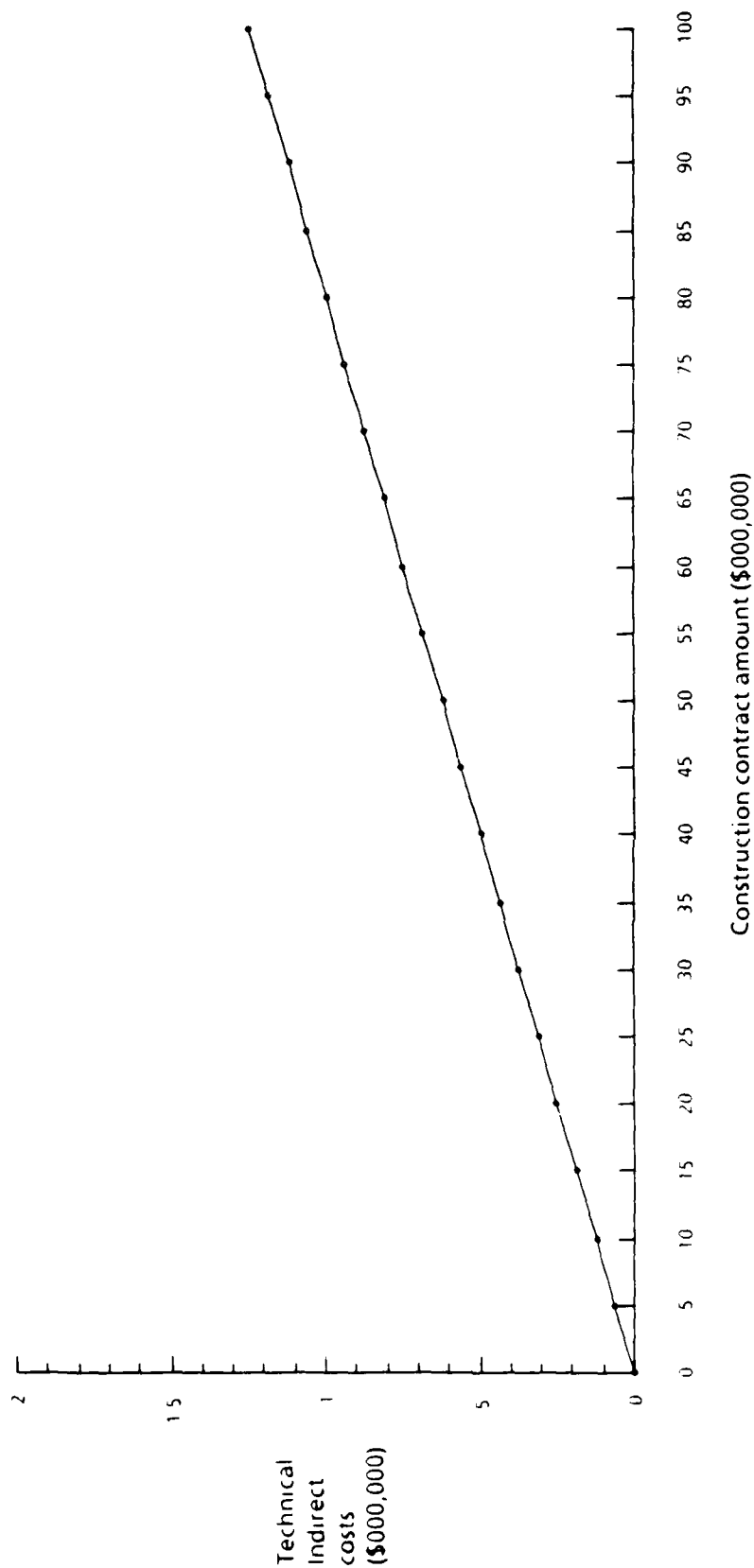**FIG. C-40. SUPERVISORY & ADMINISTRATIVE COSTS FOR MULTIPURPOSE POWER PROJECTS AND O&M: MULTIPURPOSE POWER PROJECTS**
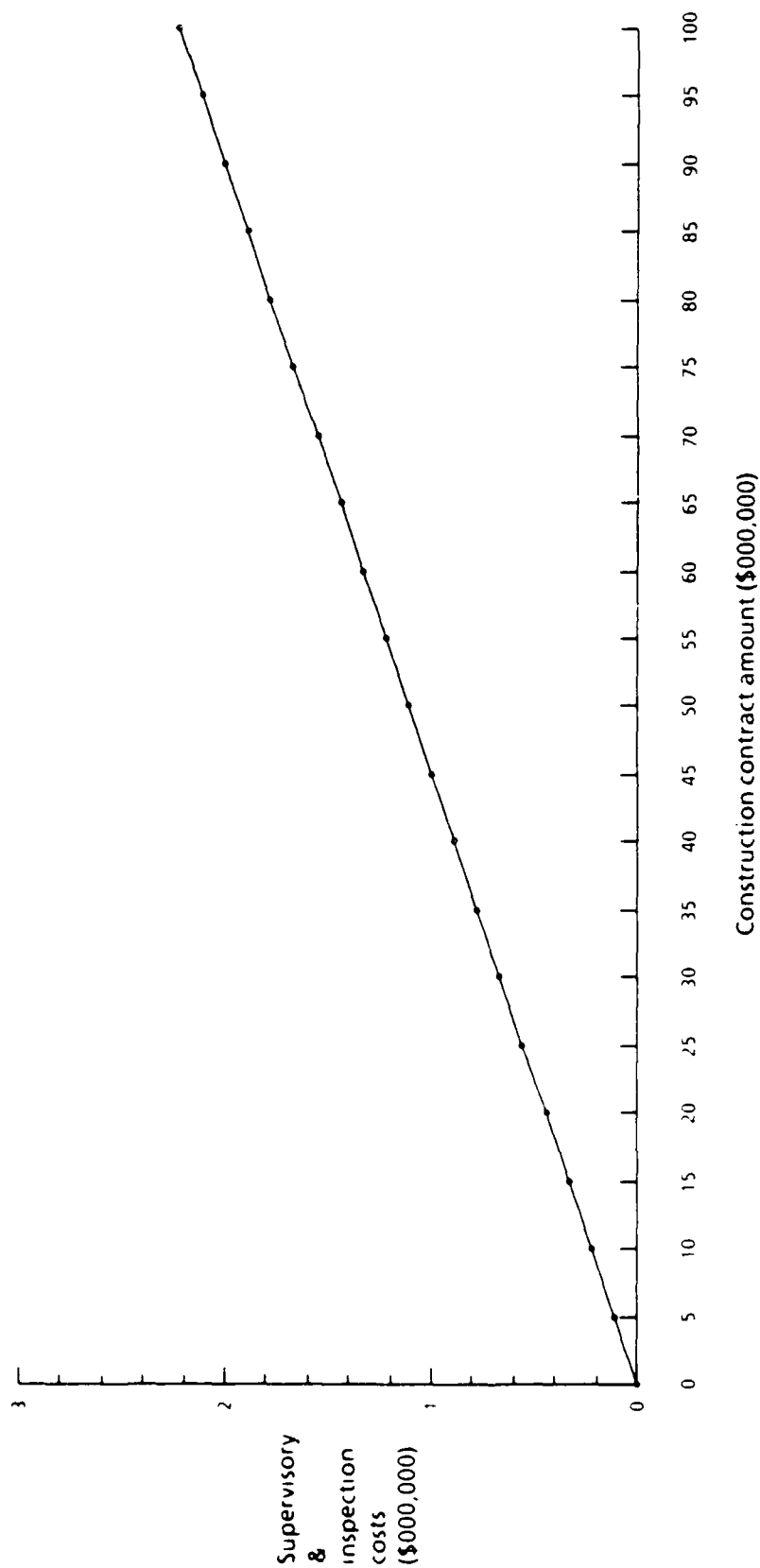
Notes: Supervisory & inspection costs = 0 022 * [Construction contract amount]
(t = 18 1) (Adjusted R Square = 0 89)

FIG. C-41. SUPERVISORY & INSPECTION COSTS FOR MULTIPURPOSE POWER PROJECTS AND O&M: MULTIPURPOSE POWER PROJECTS

Notes: General & administrative costs = 0 014 * [Construction contract amount]
(t = 17 2)   (Adjusted R Square = 0 88)

FIG. C-42. GENERAL & ADMINISTRATIVE COSTS FOR MULTIPURPOSE POWER PROJECTS AND O&M: MULTIPURPOSE POWER PROJECTS

Total engineering costs ($000,000)

Construction contract amount ($000,000)

Notes: Total Engineering Costs = 0.089 * [Construction Contract Amount]

(t = 9.1)   (Adjusted R-Square = 0.61)

FIG. C-43. TOTAL ENGINEERING COSTS FOR BEACH EROSION PROJECTS AND RECREATION PROJECTS

FIG. C-44. DIRECT E&D COSTS FOR BEACH EROSION PROJECTS AND RECREATION PROJECTS

Notes: Direct E&D costs = 0.069 * (Construction contract amount)
(t = 8.4)   (Adjusted R-Square = 0.57)

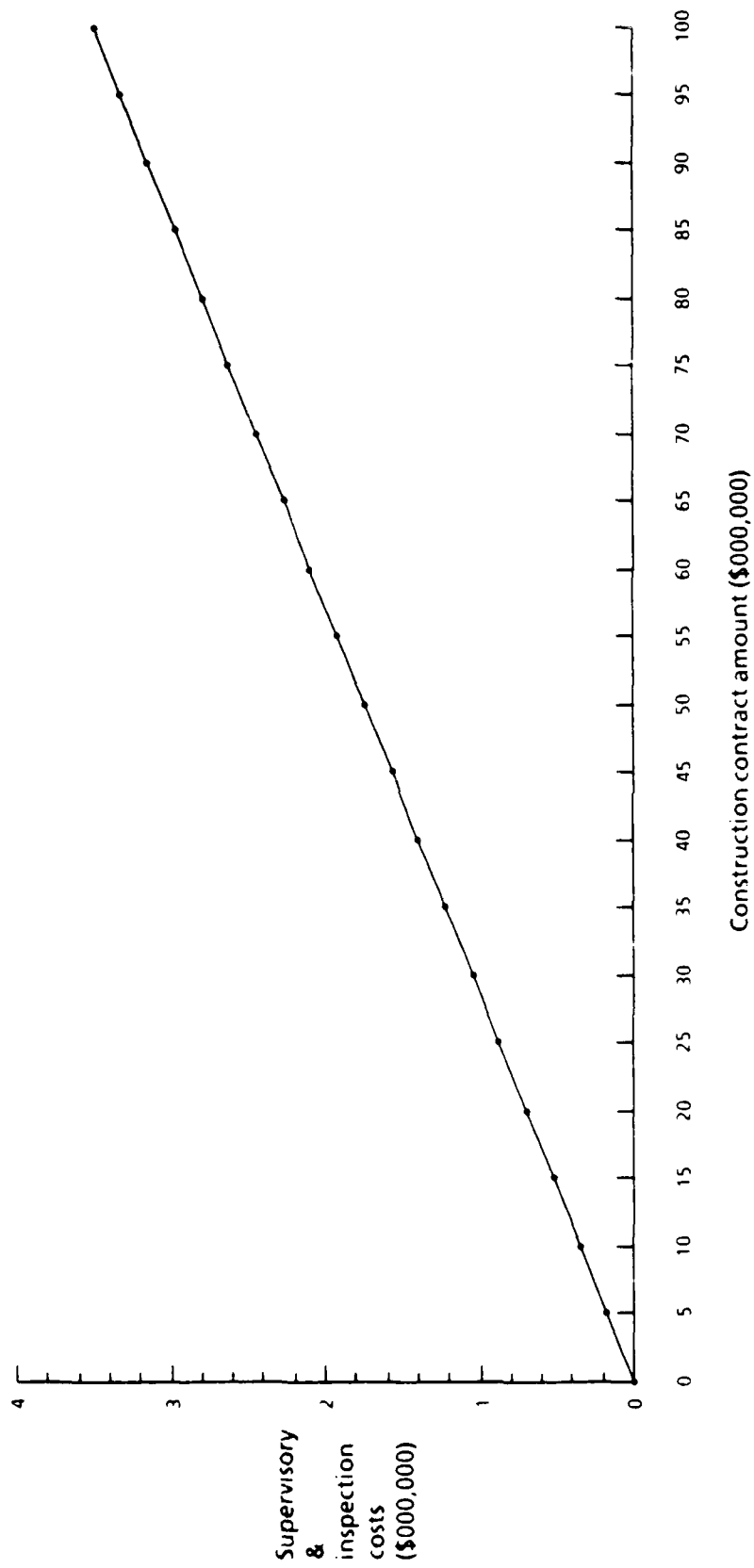Construction contract amount ($000,000)

Direct E&D costs ($000,000)

Notes: Technical indirect costs = 0.012 * [(construction contract amount)] (t = 4.6) (Adjusted R Square = 0.28)

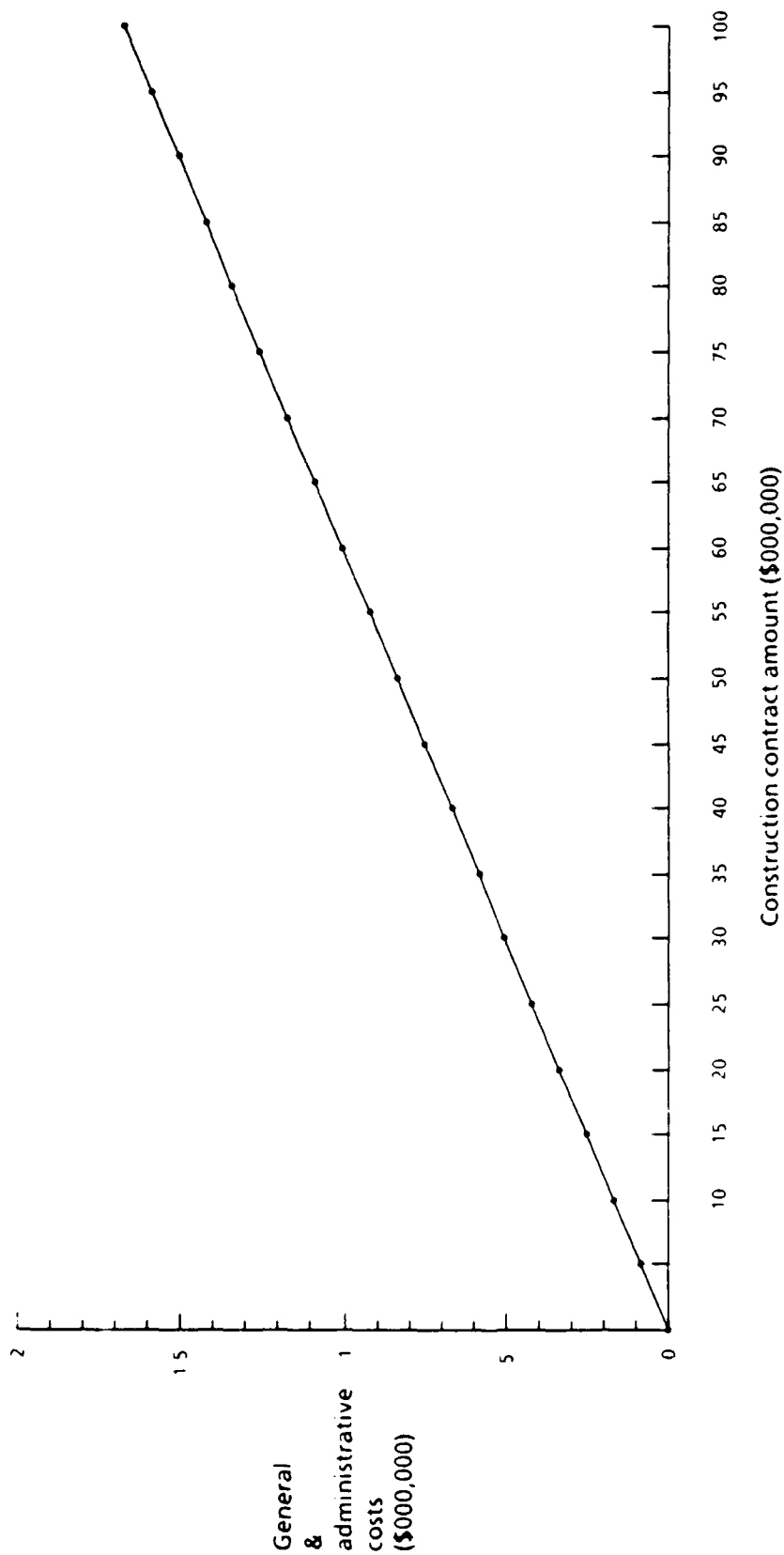**FIG. C-45. TECHNICAL INDIRECT COSTS FOR BEACH EROSION PROJECTS AND RECREATION PROJECTS**
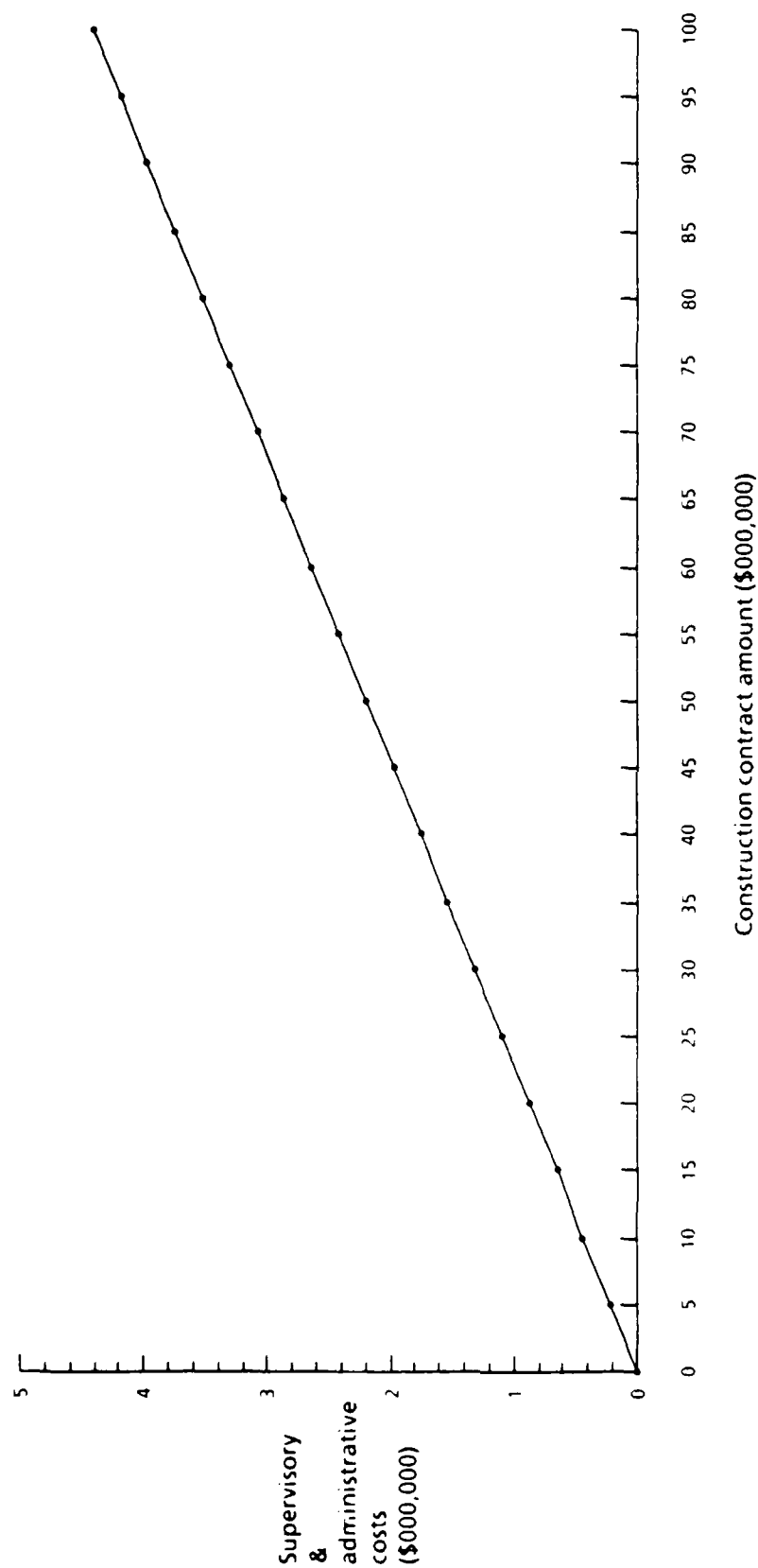
Notes: Supervisory & administrative costs = 0 044 * [Construction contract amount]
(t = 12 5)   (Adjusted R Square = 0 75)

**FIG. C-46. SUPERVISORY & ADMINISTRATIVE COSTS FOR BEACH EROSION PROJECTS AND RECREATION PROJECTS**

Notes: Supervisory & inspection costs = 0 035 * [(Construction contract amount)]
(t = 9 4)   (Adjusted R Square = 0 63)

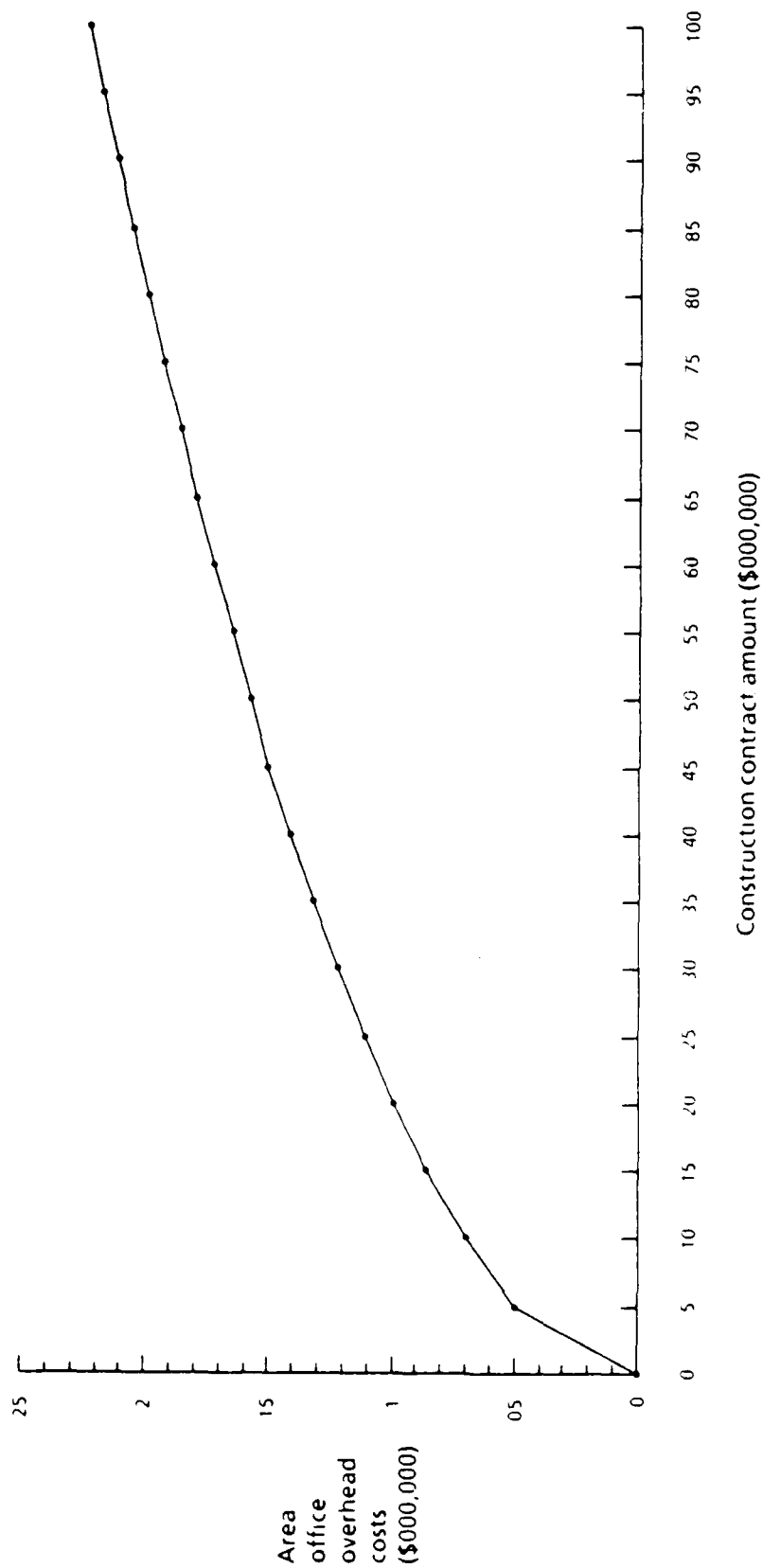**FIG. C-47. SUPERVISORY & INSPECTION COSTS FOR BEACH EROSION PROJECTS AND RECREATION PROJECTS**

Notes: General & administrative costs = 0 017 * [Construction contract amount]
(t = 11 3)   (Adjusted R-Square = 0 71)

**FIG. C-48. GENERAL & ADMINISTRATIVE COSTS FOR EACH EROSION PROJECTS AND RECREATION PROJECTS**

C-51
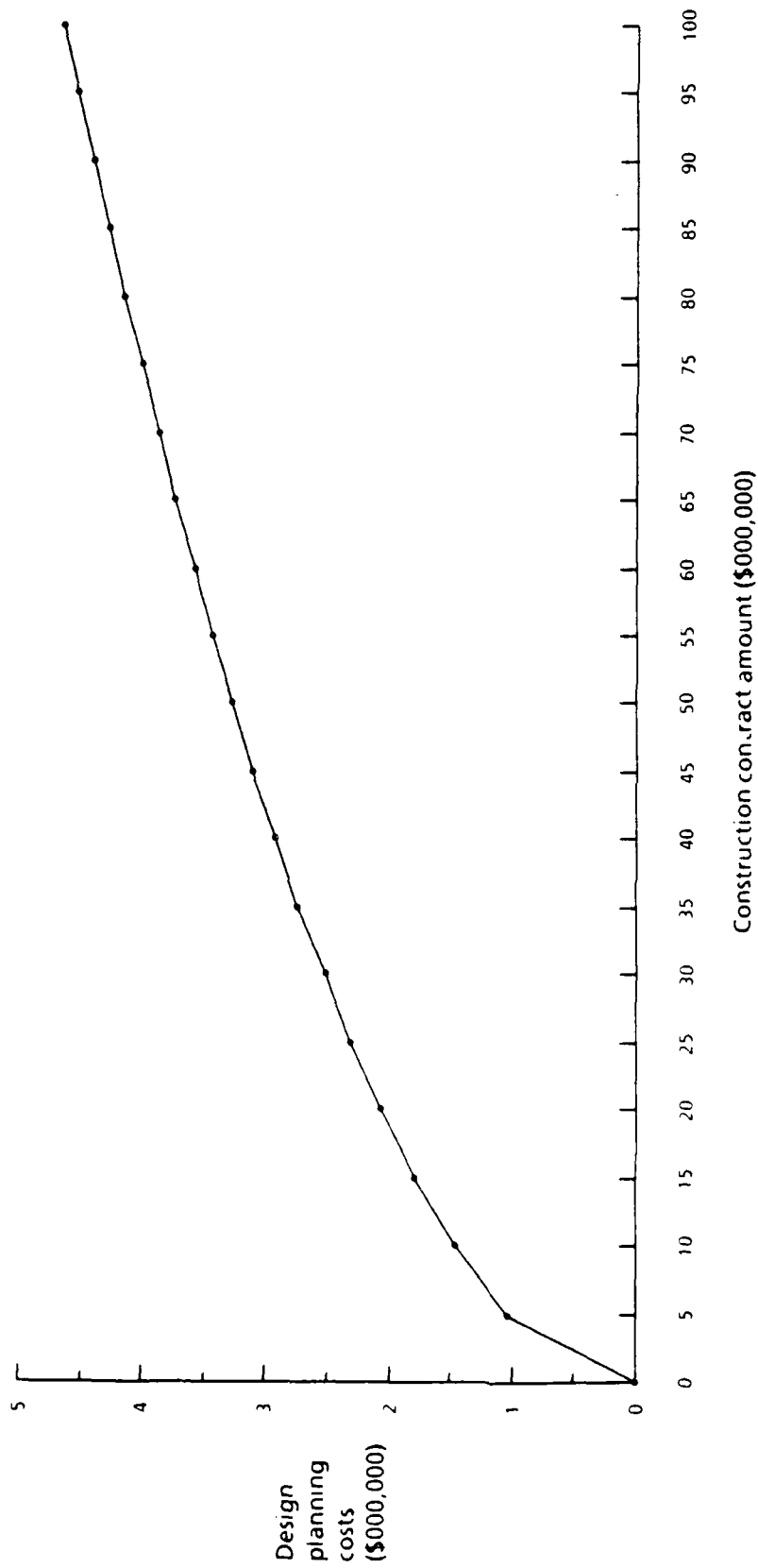
Notes: Design planning costs $= 46 *$ [Square root of construction contract amount]

$(t - 10\ 9)$ (Adjusted R Square $= 0\ 32$)

FIG. C-49. DESIGN PLANNING COSTS FOR ALL PROJECTS

Construction con.ract amount ($000,000)

Design
planning
costs
($000,000)

Area office overhead costs ($000,000)

Construction contract amount ($000,000)

Notes: Area office overhead costs = $.2 *$ (Square root of construction contract amount)

(t = /4)   (Adjusted R-Square = 0.24)

FIG. C-50. AREA OFFICE OVERHEAD COSTS FOR ALL PROJECTS
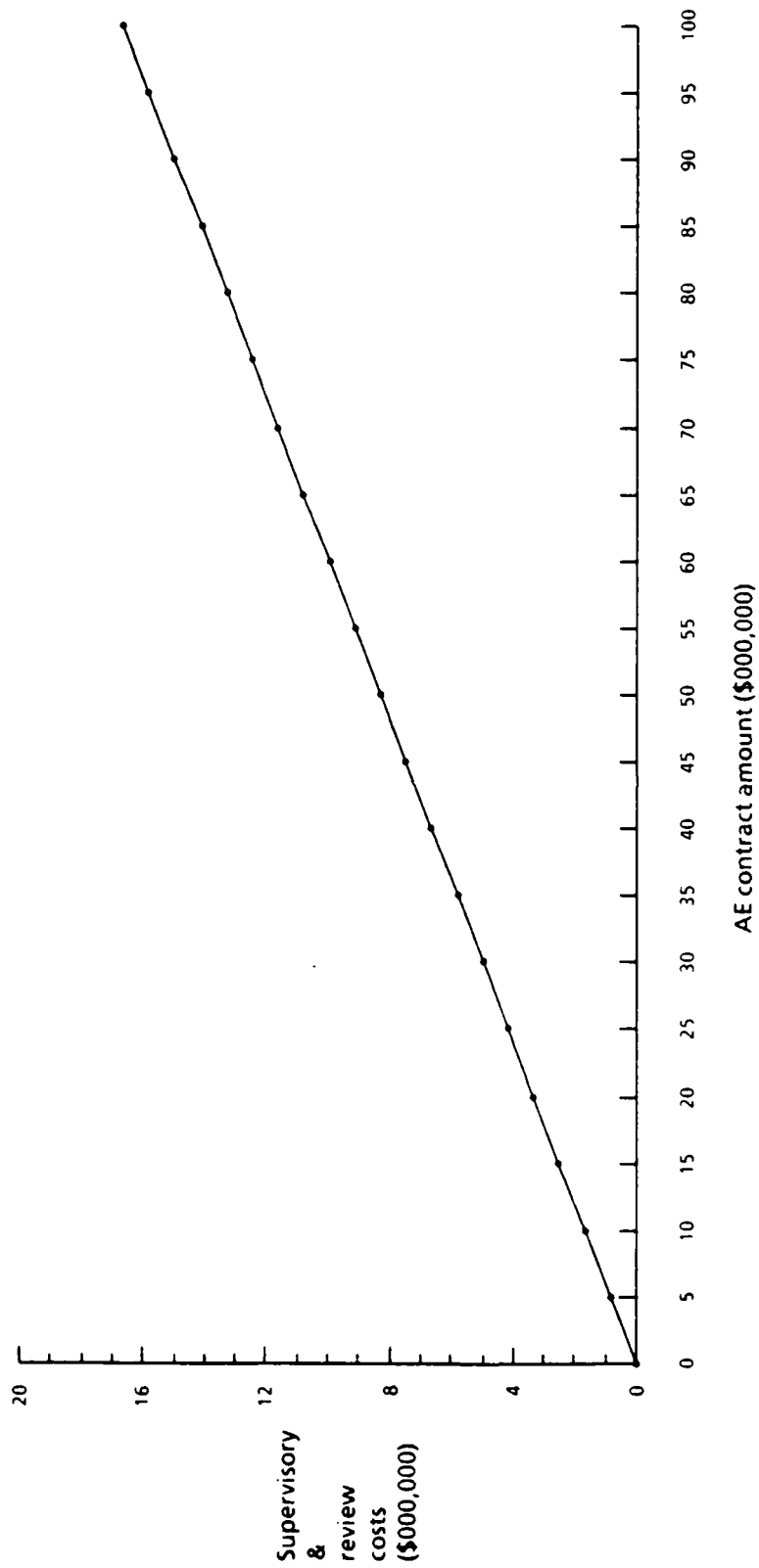
Notes: Supervisory & review costs = 0 166 * (AE contract amount)
(t = 18 0)   (Adjusted R-Square = 0 61)

FIG. C-51. SUPERVISORY & REVIEW COSTS FOR ALL PROJECTS